Final v.2

Round Two
Remedial Investigation Report
Sites 1 and 3
Naval Weapons Station Yorktown
Yorktown, Virginia

Text - Volume I of II

Prepared For

Department of the Navy
Atlantic Division

Naval Facilities Engineering Command

Norfolk, Virginia

Under The

LANTDIV CLEAN Program

Comprehensive Long-Term Environmental Action Navy

Reference:
Contract
N62470-89-D-4814

CTO-0318

May 1998

Baker

FINAL$_{V.2}$

ROUND TWO
REMEDIAL INVESTIGATION REPORT
SITES 1 AND 3

NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

CONTRACT TASK ORDER 0318

MAY 22, 1998

Prepared for:

DEPARTMENT OF THE NAVY
ATLANTIC DIVISION
NAVAL FACILITIES
ENGINEERING COMMAND
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LIST OF ACRONYMS AND ABBREVIATIONS

µg/kg	Microgram per Kilogram
µg/m^3	Microgram per Cubic Meter
µg/g	Micrograms per gram
µg/L	Microgram per Liter
1,2-DCE	1,2-dichloroethene
1,2-DCA	1,2-dichloroethane
4,4'-DDT	4,4'-diphenyltrichloroethane
ABS	adsorption factor
AET	Apparent Effects Threshold
AF	soil to skin adherence factor
AMTRAC	Amphibians Fractor
AOC	Area of Concern
AQTESOLV	Aquifer Test Solver Program
AQUIRE	Aquatic Information Retrieval Database
ARARs	Applicable or Relevant and Appropriate Requirements
ARL	Aquatic Reference Level
ASTDR	Agency for Toxic Substances and Disease Registry
ASTM	American Society for Testing Materials
AT	averaging time
ATc	averaging time carcinogen
ATnc	averaging time noncarcinogen
ATV	All-Terrain Vehicle
AWQC	Ambient Water Quality Criteria
Baker	Baker Environmental, Inc.
B_b	Beef Transfer Coefficient
B_r	Plant Transfer Coefficient
B_v	Plant Transfer Coefficient
BCF	Biological Concentration Factor
bgs	Below Ground Surface
BI	biotoxic index
BOD	biological oxygen demand
BRA	Baseline Risk Assessment
BRAC	Base Realignment and Closure
BSAF	Biota to soil/water/sediment accumulation factor
BSL	BTAG Screening Level
BTAG	Biological Technical Assistance Group
BW	body weight
CAMA	Coastal Area Management Act
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CF	conversion factor
CFR	Code of Federal Regulations
cis-1,2-DCE	cis-1,2-dichloroethene

LIST OF ACRONYMS AND ABBREVIATIONS
(continued)

CLEAN	Comprehensive Long-Term Environmental Action Navy
CLP	Contract Laboratory Program
cm/sec	centimeters per second
CNS	central nervous system
CO	Carbon Monoxide
COC Values	Chemical of Concern Screening Concentrations
COC	chemical of concern
COD	chemical oxygen demand
COPC	contaminant of potential concern
CPF	carcinogenic potency factor
CRAVE	Carcinogen Risk Assessment Verification Endeavor
CRDL	Contract Required Detection Limit
CRQL	Contract Required Quantitation Limit
CS	Confirmation Study
CSA	Comprehensive Site Assessment
CSF	Carcinogenic Slope Factor
CSM	conceptual site model
CT	central tendency
CTO	Contract Task Order
cu.yd.	Cubic Yard
CWA	Clean Water Act
DAD	Dermally Absorbed Dose
D.O.	Dissolved Oxygen
DDD	1,1-dichloro-2,2-bis(p-chlorophenyl)ethane
DDE	1,1-dichloro-2,2-bis(p-chlorophenyl)ethylene
DDT	diphenyltrichloroethane
DEM	Division of Environmental Management
DOD	Department of Defense
DoN	Department of the Navy
DQO	data quality objective
ECAO	Environmental Contaminant Assessment Office
ECD	electron capture detector
ECOC	Ecological Contaminant of Concern
ED	exposure duration
EF	exposure frequency
Eh	Oxidation Reduction Potential
EI	Ecological Index
EL	exposure level
EMD	Environmental Management Division
EOD	Explosive Ordnance Disposal
EPA	Environmental Protection Agency (U.S.)
ER-L	Effects Range-Low
ER-M	Effect Range - Median
ERA	ecological risk assessment
ESQD	Explosive Safety Quantity Distance

LIST OF ACRONYMS AND ABBREVIATIONS
(continued)

ET	exposure time
eV	Electron Volt
FAWQC	Federal Ambient Water Quality Criteria
FFA	Federal Facilities Agreement
F_i	fraction ingested from source
FID	flame ionization detector
f_{oc}	sediment particle grain size
FS	Feasibility Study
FSAP	Field Sampling and Analysis Plan
FSP	Field Sampling Plan
FWQSV	Freshwater Water Quality Screening Values
FWS	Fish and Wildlife Service
FY95 SMP	Fiscal Year 1995 Site Management Plan
gpd/ft	gallons per day per foot
gpm	gallons per minute
H	mean species diversity
HA	health advisory
HASP	Health and Safety Plan
HEAST	Health Effects Assessment Summary Tables
HHAG	Human Health Assessment Group
HHRA	Human Health Risk Assessment
HI	Hazard Index
HQ	Hazard Quotient
HQW	high quality water
i	hydraulic gradient
IAS	Initial Assessment Study
ICR	Incremental Cancer Risk
ID	inside diameter
IDW	Investigative Derived Wastes
IR	ingestion rate
IRA	interim remedial action
IRIS	Integrated Risk Information System
IRP	Installation Restoration Program
K	hydraulic conductivity
K_d	Soil Sorption Coefficient
K_{oc}	Organic Carbon Partition Coefficient
K_{ow}	Octanol-Water Partition Coefficient
K_p	Permeability Constant

LIST OF ACRONYMS AND ABBREVIATIONS
(continued)

LANTDIV	Naval Facilities Engineering Command, Atlantic Division
LOAEL	lowest-observed-adverse -effect level
MBI	Macroinvertebrate Biotic Index
MCL	Maximum Contaminant Level
MF	Modifying Factor
mg/kg	Milligram per Kilogram
mg/L	Milligrams per Liter
mgd	million gallons per day
MI	Mobility Index
ml	milliliter
mL/g	milliliters per gram
mmhos/m	Millimhos per Meter
msl	Mean Sea Level
MW	monitoring well
nPAH	non-carcinogenic Polynuclear Aromatic Hydrocarbon
NACIP	Navy Assessment and Control of Installation Pollutants
Navy CLEAN	Comprehensive Long-Term Environmental Action Navy Program
N_e	effective porosity
NCEA	National Center for Environmental Assessment
NCP	National Contingency Plan
NCWP	Near Coastal Waters Program
NEDED	Naval Explosives Development Engineering Department
NEESA	Naval Energy and Environmental Support Activity
NEHC	Navy Environmental Health Center
NEP	National Estuary Program
NFG	National Functional Guidelines
NOAA	National Oceanographic and Atmospheric Administration
NOAEL	No-Observed-Adverse-Effect-Level
NOEL	No-Observed-Effect-Level
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NPS	National Park Service
NPW	Net Present Worth
NSW	nutrient sensitive waters
NTR	Navy Technical Representative
NTU	Nephelometric Turbidity Unit
NWI	National Wetlands Inventory
O&G	oil and grease
O&M	Operation and Maintenance
O_3	Ozone
OD	outside diameter
ORNL	Oak Ridge National Laboratory
OU	Operable Unit

LIST OF ACRONYMS AND ABBREVIATIONS
(continued)

PAH	polynuclear aromatic hydrocarbon
PC	permeability constant
PCB	Polychlorinated Biphenyls
PCE	tetrachloroethene
PEF	particulate emissions factor
pH	measure of acidity/alkalinity
PHA	public health assessment
PID	Photoionization Detector
PM 10	Particulate Matter Smaller Than 10 Microns
PMCL	Primary Maximum Contaminant Level
POTW	Public Owned Treatment Works
ppb	parts per billion
PPE	Personal Protective Equipment
ppm	parts per million
psi	pounds per square inch
PVC	polyvinyl chloride
pw	pumping well
QA/QC	Quality Assurance/Quality Control
QAPP	Quality Assurance Project Plan
QC	Quality Control
QI	quotient index
RA	Risk Assessment
RAA	Remedial Action Alternative
RAB	Restoration Advisory Board
RAGS	Risk Assessment Guidance for Superfund
RBC	Risk-Based Concentration
RCRA	Resource Conservation and Recovery Act
RfC	Reference Concentration
RfD	Reference Dose
RI/FS	Remedial Investigation/Feasibility Study
RI	Remedial Investigation
RMC	RMC Environmental Services, Inc.
RME	Reasonable Maximum Exposure
ROD	record of decision
RPD	Relative Percent Difference
S	storativity, water solubility
SA	skin area
SAP	Sampling and Analysis Plan
SARA	Superfund Amendments and Reauthorization Act
SB	soil boring
SC	commercial shellfishing
SCCRBS	Selection of Contaminants of Concern by Risk-Based Screening
SCS	Soil Conservation Service
SD	sediment

LIST OF ACRONYMS AND ABBREVIATIONS
(continued)

SDWA	Safe Drinking Water Act
SI	Site Inspection
SM	silty sand
SMCL	Secondary Drinking Water Regulations
SMP	Site Management Plan
SO_2	Sulfur Dioxide
SOP	Standard Operating Procedures
SP	poorly graded sand
SPT	Standard Penetration Test
sq.ft.	Square Foot
sq.yd.	Square Yard
SQC	Sediment Quality Criteria
SSA	Site Screening Area
SSL	Sediment Screening Level
SSSL	Surface Soil Screening Level
STP	Sewage Treatment Plant
SU	standard units
SVOC	Semivolatile Organic Compound
SW	surface water
SWMU	Solid Waste Management Unit
SWSL	Surface Water Screening Level
T	transmissivity
T.V.	Turbidity Units
TAL	Target Analyte List
TBC	To Be Considered
TCA	1,1,1-trichloroethane
TCE	trichloroethene
TCL	Target Compound List
TCLP	Toxicity Characteristic Leaching Procedure
TDS	total dissolved solids
TDI	Total Daily Intake
TEF	toxicity equivalency factor
TICs	tentatively identified compounds
TKN	Total Kjeldahl Nitrogen
TOC	Total Organic Carbon, Top of Casing
TPH	total petroleum hydrocarbons
trans-1,2-DCE	trans-1,2-dichloroethene
TRC	Technical Review Committee
TRV	toxicity reference value
TSCA	Toxic Substance Control Act
TSS	total suspended solids
UCL	Upper Confidence Limit
UF	uncertainty factor
USCOE	United States Corps of Engineers
USCS	Unified Soil Classification System

LIST OF ACRONYMS AND ABBREVIATIONS
(continued)

USDA	Untied States Department of Agriculture
USDI	United States Department of Interior
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
UXO	Unexploded Ordnance
VC	Vinyl Chloride
VDEQ	Virginia Department of Environmental Quality
VF	Volatilization Factor
VHWMR	Virginia Hazardous Waste Management Regulations
VOA	Volatile Organic Analysis
VOC	Volatile Organic Compound
VP	Vapor Pressure
VR	Virginia Regulation
VSWCB	Virginia State Water Control Board
VWQS	Virginia Water Quality Standard
V_x	average seepage velocity
WAR	Water and Air Research, Inc.
WES	Waterways Experimental Station
WOE	weight of evidence
WPNSTA Yorktown	Naval Weapons Station Yorktown, Yorktown, Virginia
WQS	Water Quality Standards (Virginia)
WQSV	water quality screening values
WS	Wilderness Society
°F	Degrees Fahrenheit

EXECUTIVE SUMMARY

This report presents the results of the Round Two Remedial Investigation (RI) completed for Sites 1 (Dudley Road Landfill) and 3 (Group 16 Magazines Landfill) at the U.S. Naval Weapons Station Yorktown (WPNSTA Yorktown), Yorktown, Virginia. This RI Report has been prepared by Baker Environmental, Inc. (Baker) under the Department of the Navy's (DoN's) Comprehensive Long-Term Environmental Action Navy (CLEAN) contract administered by the Naval Facilities Engineering Command, Atlantic Division (LANTDIV).

The objectives of this RI are: (1) to conduct a Round Two remedial investigation based on the results of the Round One RI; (2) to assess the nature and extent of contamination at each site and/or to address data gaps observed after the Round One RI preventing an adequate understanding of site conditions; and (3) to assess potential human health and ecological risks associated with any contamination at Sites 1 or 3 and identify any potential remaining data gaps.

Site 1 is a 6-acre area located just north of the headwaters of Indian Field Creek. The landfill was in use from approximately 1965 to 1979 for general disposal, with one area reportedly used for disposal of plastic lens grinding waste until 1983. The site was originally used for sand mining. There are two unfilled sand borrow pits at the site. One is located within the eastern portion of the site quadrant and is vegetated with loblolly pine. The second unfilled borrow pit is within the southwest portion of the site and accumulates surface water run off. The water within this unfilled borrow pit fluctuates greatly throughout the year from a few inches to approximately 2-feet deep. The water level of the pond fluctuates greatly. Seasonal ponding also occurs in the southeastern section of the site. Wastes reportedly disposed within the depression created by sand mining include asbestos insulation from steam piping; oil, grease, paint, and solvent containers; nitramine-contaminated carbon; household appliances; scrap metal banding; construction rubble; plastic lens grinding wastes; tree limbs; lumber; packaging wastes; electrical wires; and waste oil. The landfill received an estimated 255 tons of waste during the time in which the site was in use. The landfill is covered by approximately two feet of soil and the abandoned sand reclamation area is covered by 8 feet of soil (Final Master Project Plans, Baker, 1994a).

On January 12, 1979 the VADEQ performed an inspection of the site. The landfill did not meet the requirements for a permitted landfill by the Virginia Department of Health governing the disposal

of solid waste. The deficiencies were corrected and the landfill received approved waste until 1985 when the facility was closed. Another inspection conducted of the closed disposal facility on August 29, 1995 (by VADEQ), found deficiencies (subsidence and ponding water) within the landfill cover. The station replied that this noncompliance item will be addressed under the IR program.

Site 3 is a 2-acre area located behind the Group 16 Magazines, just south of Site 1 (separated from Site 1 by a ravine), along the headwaters of Indian Field Creek. The landfill is named for its proximity to the Group 16 Magazines. The history of this landfill is unrelated to operations at the magazines. The landfill area was reportedly in use from 1940 to 1970. The site was originally used for sand mining. Wastes that were disposed within the depression (unfilled sand borrow pit) created by sand mining include solvents, sludge from boiler cleaning operations, grease trap wastes, Imhoff tank skimmings containing oil and grease, and animal carcasses. This landfill received an estimated 90 tons of waste during the time in which the site was in use. Currently, most of the site, which is overgrown with trees, is covered by approximately two feet of soil with some scattered surface debris (Final Master Project Plans, Baker, 1994a).

Previous investigation reports completed through the IRP at WPNSTA Yorktown include the following:

- Initial Assessment Study (IAS) (C. C. Johnson & Associates, Inc. and CH2M Hill, 1984)
- Confirmation Study Rounds One and Two Reports (Dames and Moore, 1986 and Dames and Moore, 1988)
- RI Interim Report (Versar, 1991)
- Focused Biological Sampling and Preliminary Risk Evaluation Report (Baker, 1993b)
- Round One RI Report (Baker/Weston, 1993a)

- Habitat Evaluation Report (Baker, 1994b)

Additionally, a confirmation sample from one groundwater monitoring well was collected on July 12, 1995 (Baker) and analyzed to confirm results from the Round One RI report. These reports have been generated in conjunction with the continuing development of the DoD IRP.

STUDY AREA INVESTIGATION

The Round Two field program at Sites 1 and 3 was designed to provide information necessary to characterize potential human health effects and ecological impacts resulting from previous site activities.

Data gathered during the Round One RI indicated potential groundwater contamination within the area of monitoring well 1GW12 at Site 1 and in subsurface soil and groundwater at Site 3. However, the extent of potential contamination could not be defined. In addition, soil samples were collected from the 0- to 2-foot interval, which is no longer consistent with 0- to 6-inch soil samples used in human health risk assessments. Therefore, the field program conducted at Sites 1 and 3 under this investigation was designed to further evaluate the extent of contamination in surface soil, subsurface soil, groundwater, surface water, sediment, and biota to provide data for human health and ecological risk assessments. Included in these objectives is to define the vertical extent of the buried debris at the landfill areas at both sites.

The field investigation at Sites 1 and 3 commenced in late January 1996 and continued until the mid February 1996. Groundwater monitoring wells were installed, test pits were excavated, and surface soil, subsurface soil, and groundwater samples were collected. Surface water, sediment, and biota samples were also collected within Indian Field Creek.

Site 3 Confirmation Sampling

On August 26, 1996, six soil samples were collected to confirm the elevated SVOC concentrations detected in surface soil sample 3SS10 as shown on Figure 2-1. Five (3SS10A, 3SS10C through 3SS10F) of the samples were collected at the approximate location of 3SS10 at a spacing of 15 feet. One sample (3SB10B) was collected at the 3SS10A location at a depth of 1.5 - 2.0 ft. bgs.

All six of the samples were analyzed for TCL semivolatile organics.

NATURE OF CONTAMINATION

Site 1 Analytical Results

Surface Soil Investigation Results

The results of the Round One RI were used to select sampling locations for the Round Two RI. In general, the results of the Round Two surface soil investigation at Site 1 were consistent with the Round One results.

Generally, low concentrations of semivolatile organic compounds (SVOCs), mainly polynuclear aromatic hydrocarbons (PAHs) were detected within twelve of the twenty-one surface soil samples (including duplicates) collected at Site 1.

Low concentrations of the pesticide compounds dieldrin, 4-4-dephenyltrichloroethane (4,4-DDT), alpha-chlordane, and gamma-chlordane were detected at within one sample (1GW19-00) and low levels of aroclor-1260 was detected in 1GW18-00. Nitramine compounds were not detected in any surface soil samples.

Fifteen of 20 inorganics were detected in surface soil samples. Mercury, silver, thallium, and cyanide were not detected in the sample set.

Two inorganic compounds (arsenic and lead) were detected at levels exceeding station wide background concentrations. Arsenic was detected in the sample 1SB12A-00 at a concentration of 92.5 mg/kg and lead was detected at a concentration of 62.3 mg/kg in the sample 1SB19-00. The most prevalent chemical of potential concern (COPCs) detected within the sample set are arsenic, beryllium, and iron. Detections of aluminum were less frequent.

Subsurface Soil Investigation Results

Subsurface soil samples collected at soil boring and test pit locations.

No VOCs were detected in the subsurface soils. Low concentrations of SVOCs were detected at two locations (1GW12 and 1GW18) within the western portion of the site.

Six pesticide compounds were detected within one sample (1GW19-01;1-to 3-ft bgs) at relatively low concentrations. Similar compounds and concentrations were detected in the surficial soil sample collected at this location. In addition, one polychlorinated biphenyl (PCB) compound (aroclor-1260) was detected at low concentrations at the same location but at a greater depth (3- to 5-ft bgs). This same PCB compound was detected at low concentrations at 1GW20 (1- to 3-ft bgs).

Nitramines were not detected in the subsurface soil samples.

Sixteen of 20 inorganics were detected within the subsurface soil samples, mercury, silver, thallium and cyanides were not detected in the sample set.

The inorganic analytes above station-wide background levels were identified at two locations. Cadmium was detected at low levels (background concentrations were nondetect) at locations 1SB12A and 1SB19. Additional inorganics detected above background concentrations include arsenic at 1SB12 (126 mg/kg; 1- to 3- ft. bgs) and lead at 1SB19 (57.4 mg/kg; 1- to 3- ft. bgs). The most prevalent COPCs detected were arsenic, beryllium, and iron. Detections of aluminum, antimony, and manganese were less frequent.

Four test pits were excavated within the suspected landfill area. The test pits were excavated to depths of 4.5- to 8-feet bgs when the natural soil horizon was determined. Test pit 1TP01 was excavated north of the dirt access road. The soil in this area was determined to be natural therefore, the landfill does not extend north of the road at this location. Through the excavation of remaining test pits it was determined that there was approximately 6- to 7-feet of fill material covering the landfill. The fill material consisted of sandy soil with a mixture of debris (concrete, scrap metal, styrofoam, wood, rail road ties, and tree limbs) In addition, a 6- to 8-inch layer of white lenses grinding dust was encountered at approximately 3-feet bgs within 1TP04.

Groundwater Investigation Results

Shallow groundwater

Volatile organic compounds (VOCs), SVOCs, and nitramines were detected in seven of the eleven shallow groundwater samples collected at Site 1.

Three of the monitoring wells (1GW12, 1GW19, and 1GW20) had concentrations of 1,2-dichloroethene and trichloroethene. The highest concentration of trichloroethene (190 µg/L) detected in 1GW20 exceeded the Federal maximum contaminant levels (MCLs) and the Virginia MCLs. This monitoring well was located in an area adjacent to where metal drums were found at the surface during a site visit in March, 1995. The concentrations of trichloroethene (64 µg/L) and 1,2-dichloroethene (40 µg/L) detected at 1GW12 were attributed to blank contamination by the validator. Previous sampling of this monitoring well during the Round One RI indicated elevated concentrations of trichloroethene (TCE) (18,000 µg/L) and 1,2-dichloroethene (1,2-DCE) (1,000 J µg/L). In July, 1995 the monitoring well was sampled to confirm the Round One results and concentrations of TCE (3,900 µg/L) and cis-1,2-DCE (520 µg/L) were detected.

Low concentrations of pentachlorophenol and nitrobenzene were detected in four of the samples collected.

Relatively low concentrations of total inorganics were detected in the shallow groundwater samples. Thirteen of 20 inorganics were detected within the sample set. Antimony, beryllium, mercury, nickel, silver, thallium and cyanide were not detected. Only four samples exceeded station wide background levels for at least one of the following analytes: cadmium, iron, manganese and zinc. Only cadmium exceeded the Federal MCLs at a concentration of 8.6 µg/L at 1GW12. Arsenic, iron, and manganese were the prevalent COPCs detected.

Twelve of 20 dissolved inorganics were detected in the sample set. Antimony, beryllium, chromium, mercury, selenium, silver, thallium, and cyanide were not detected.

Concentrations of dissolved inorganics exceeded Station-wide background levels in at least one of the following analytes: aluminum, barium, cadmium, cobalt, copper, iron, lead, manganese, nickel, and zinc. Only cadmium exceeded the Federal MCLs at a concentration of 9.0 µg/L at 1GW12.

The difference in concentrations of TCE and 1,2-DCE at monitoring well 1GW12 between the Round One and Two sampling events may be explained by the following paragraph. The Round one data (July, 1992) indicated the presence of TCE and 1, 2-DCE within monitoring well 1GW12 at concentrations of 18,000 µg/L and 1,000 µg/L, respectively. Prior to the development site-specific work plans the well was resampled (July 1995) to confirm the Round One data. The concentrations of TCE and 1,2-DCE were significantly lower at 3,900 µg/L and 520 µg/L, respectively. Monitoring well 1GW12 was resampled during the Round Two RI (February, 1996) using low-flow techniques to minimize the agitation in the well, preventing volatilization and the entrainment of fine particulate matter in the sample matrix. TCE and 1,2-DCE were detected at concentrations of 64B µg/L and 40J µg/L, respectively. In addition, a shallow monitoring well (1GW19) upgradient of 1GW12 had detectable concentrations of TCE at 4J µg/L and the downgradient well 1GW20 had concentrations of TCE at 190 µg/L and 1,2-DCE at 52 µg/L. These concentrations support the Round Two results at well 1GW12. In addition, two deeper monitoring wells installed within the lower Cornwallis Cave/Yorktown-Eastover aquifer showed TCE concentrations of 360 µg/L (1GW12B at approximately 30 to 50 ft. bgs) and 46B µg/L (1GW12A at approximately 50 to 65 ft. bgs). The July and Round Two data for well 1GW12 indicate significant attenuation of TCE and 1,2-DCE in shallow groundwater. A possible explanation for the attenuation of TCE and 1,2-DCE may be the groundwater flow velocity and the proximity of well 1GW12 to a ravine located directly downgradient. The shallow groundwater flow velocity is approximately 1.2 feet per day toward the direction of the ravine. The higher concentrations of TCE detected during the Round One RI may have migrated toward the ravine emanating with the groundwater along the steep slope (damp to wet surface soil conditions were observed in this area during the Round Two field investigation). The horizontal component of contamination migration is likely more significant than the vertical component because the Round Two data did not indicate significant TCE contamination at depth. In addition, any vertical migration of TCE may have traveled through a breach in the Cornwallis Cave Confining unit that was eroded through the formation of the ravine.

Deep groundwater

VOCs, and SVOCs were detected in three of the six deep groundwater samples (incuding duplicates) collected at Site 1.

Three of the monitoring wells (1GW12A, 1GW12B, and 1GW21) had concentrations of trichloroethene. The highest concentration of trichloroethene (360 µg/L) detected in 1GW12B exceeded both the Federal MCLs and the Virginia MCLs. This well was located near an area where TCE was detected in the shallow groundwater (1GW20 at 190 µg/L). The concentrations of trichloroethene (46 µg/L) detected at 1GW12A were attributed to blank contamination by the validator. Low concentrations of SVOCs were detected in at three of the six deep monitoring wells.

Fifteen of 20 inorganics were detected at relatively low concentrations. Antimony, mercury, silver, thallium, and cyanide were not detected.

Relatively low concentrations of total inorganics were detected the deep groundwater samples. Only one sample (1GW13A-01 and the duplicate) exceeded station wide background levels for the following analytes: aluminum, barium, cadmium, chromium, copper, iron, lead, manganese, nickel, vanadium and zinc. Only chromium exceeded the Federal MCLs at a concentration of 154 µg/L at 1GW13A.

Low concentrations of eight dissolved inorganics were detected the deep groundwater samples. Only two samples (11GW11AF-01 and 1GW21F-01) exceeded station wide background levels for lead at concentrations of 0.86 µg/L and 2.4 µg/L, respectively. Federal or state of Virginia groundwater criteria was not exceeded by of the sample concentrations.

Surface Water, Sediment, and Biota Investigation

Surface Water Investigation Results

Three surface water samples were collected from the Indian Field Creek sampling locations. Locations 1SW13 and 1SW14 were dry therefore samples could not be collected.

No VOCs, SVOCs, pesticides/PCBs or nitramines were detected in the samples.

Aluminum, barium, cadmium, copper, iron, lead, manganese, vanadium and zinc were detected at relatively low concentrations within the sample set. Only the concentrations of cadmium and copper exceeded Station-wide background levels.

Sediment Investigation Results

VOCs, SVOCs, pesticides/PCBs and nitramines were not detected in any of the sediment samples collected at five locations at Site 1.

Thirteen of 20 inorganics were detected in the sediment samples. Antimony, beryllium, cobalt, mercury, silver, thallium and cyanide were not detected within the sample set.

Arsenic, cadmium and lead exceeded Station-wide background levels in three of the samples (1SD15-01, 1SD16-01D, and 1SD16-02).

Biota Investigation Results

The biota investigation for the Round Two investigation included benthic macroinvertebrate sampling and fish population sampling. These results are presented in Ecological Risk Assessment section.

Site 3 Investigative Results

Surface Soil Investigation Results

Low concentrations of SVOCs, mainly PAHs were detected within one (3SB08A-00) of the sixteen surface soil samples collected at Site 3. A second sample 3SS10 had detections of similar PAHs but at elevated concentrations. In addition, low concentrations of pesticides were detected in the same samples. Sample 3SS11 had low concentrations (31 µg/kg) of the PCB aroclor-1260. Nitramine compounds were not detected in any surface soil samples.

Nineteen of 20 inorganics were detected in the surface soil samples. Only silver was not detected within the sample set.

Inorganic concentrations exceeded station-wide background levels in nine of the samples for at least one or more of the following analytes: antimony, barium, beryllium, chromium, iron, lead, manganese, mercury, nickel, selenium, thallium, vanadium, zinc, and cyanide. The most prevalent COPCs detected were arsenic, beryllium, and iron.

Confirmation Surface Soil Results

On August 26, 1996, five confirmatory surface (0- to 6-inches) and one subsurface (18- to 24-inches) soil samples were collected around the 3SS10 sample location as presented on Figure 4-1A. The samples were analyzed for SVOC. Further inspection of the sample locations showed a "tar-like" substance within the surficial soil (0- to 6-inches). The analytical results showed similar PAH compounds but at greatly reduced concentrations except in Sample 3SS10C which had similar (but slightly reduced) concentrations as 3SS10.

Subsurface Soil Investigation Results

Subsurface soil samples were collected at soil boring and test pit locations.

Two VOCs (1,2-dichloroethene and ethylbenzene) were detected in two samples (3TP02 and 3TP02D).

Relatively low concentrations of SVOCs were detected in three of the samples (3SB15-12, 3TP02, and 3TP02D). In addition, low concentrations of pesticides were detected in 3SB15A-12.

Nitramines were not detected in the subsurface soil samples

Nineteen of 20 inorganics were detected in the subsurface soil samples. Only silver was not detected within the sample set.

The inorganic analytes chromium, iron, mercury, selenium, and vanadium were detected slightly above station-wide background levels at four locations (3SB08A, 3SB19A, 3TP01, and 3TP02). Arsenic, beryllium and iron were the most prevalent COPCs detected.

The test pits were excavated to depths of 4- to 10-feet bgs when the natural soil horizon was determined. The subsurface soil at test pits 3TP01, 3TP03 and 3TP04 was determined to be natural at depths of less than 1-foot bgs although there was surficial debris near the locations. Results of the remaining test pit (3TP02) showed a mixture of debris (55-gal drum containing a grease-like material, wax/paraffin, scrap metal, ash, and a partially decomposed animal carcass). While excavating the test pit a 150 ppm reading was registered on the photoionization meter.

Groundwater Investigation Results

The static water level at Site 3 is approximately 5-feet above msl (Cornwallis Cave/Yorktown-Eastover aquifer) which is approximately 15 feet below the surficial aquifer (Columbia) at Site 1. In addition to the elevation difference the Columbia and Cornwallis Cave/Yorktown-Eastover aquifers are lithologically different. The Columbia aquifer consists of medium to fine sand and silt where the Cornwallis Cave/Yorktown-Eastover aquifer is generally finer-grained (silty fine sand with shell fragments). Therefore, the surficial aquifer at Site 3 is not the equivalent to the surficial aquifer at Site 1.

During the Round Two RI the existing wells were sampled and additional wells were installed. Five of the monitoring wells (3GW07, 3GW08, 3GW15, 3GW15A, 3GW19 and 3GW19A) had concentrations of trichloroethene, 1,2-dichloroethene, and vinyl chloride. The concentrations of trichloroethene ranged from 860 µg/L at 3GW19 to 10 µg/L at 3GW15A and 3GW08. The concentrations at 3GW08, 3GW15A, 3GW19 and 3GW19A exceeded both the Federal MCLs and the Virginia MCLs. In addition, concentrations of 1,2-dichloroethene at concentrations of 110 µg/L (3GW15) exceeded the Federal MCL and vinyl chloride at concentrations of 48 µg/L(3GW08) exceeded the Federal and the state of Virginia MCLs.

Relatively low concentrations of fifteen total inorganics were detected in the deep groundwater samples. Antimony, mercury, silver, thallium, and cyanide were not detected in the sample. Only one sample (3GW19-01) exceeded the Federal and the state of Virginia MCLs for chromium at a

concentration of 177 µg/L and the Federal MCL for lead at a concentration of 22 µg/L. Arsenic and iron were the most prevalent COPCs detected.

Aluminum, chromium, and manganese concentrations exceeded station-wide background levels for dissolved inorganics in seven samples (3GW08F, 3GW08AF, 3GW15F, 3GW15AF, 3GW18F, 3GW18FD and 3GW19F). There were no exceedences of the Federal or state of Virginia MCLs for dissolved inorganics within the sample set.

EXTENT OF CONTAMINATION

Site 1

Surface Soil

Following evaluation of data collected during the Round One RI, low concentrations SVOCs were identified as soil contaminants across Site 1. This is consistent with the analytical results of the Round Two sampling event. The low concentrations of SVOCs (mainly PAHs) are generally spread throughout the landfill and did not exhibit a pattern. The SVOCs detected are possibly related to past disposal practices.

Low concentrations of pesticides that were detected in one sample are consistent with historical use of Station-wide spraying. One PCB compound was detected at low concentrations at the surface soil sample collected at 1GW18 and may be attributable to past site operations.

Inorganic concentrations slightly exceeded station-wide levels for arsenic and lead in one sample for each analyte.

Overland transport of contaminated soils by runoff flowing toward Indian Field Creek is a potential pathway for surface soil contaminant migration. Analytical results from surface water/sediment samples collected in Indian Field Creek indicates that the surface soil contaminants detected at Site 1 have not migrated to or had an impact on this surface water body.

The surface soil at Site 1 has not been significantly impacted by site operations. There is no apparent source or discernible pattern of contamination within this media.

Subsurface Soil

Results of the subsurface soil investigation at Site 1 were similar to the results of the surface soil investigation. Relatively low concentrations of SVOCs (mainly PAHs) were detected at two locations.

Low levels of pesticides were detected at one location (1GW19) at a depth of 1- to 3-feet bgs. Similar compounds and concentrations were detected within the surface soil sample collected at this location. These detections are consistent with historical use of Station-wide spraying. One PCB compound was detected at low concentrations at two locations 1GW19 and 1GW20 at depths of 1- to 3-feet bgs. These concentrations were detected within the surface soil (1GW18) and may be attributable to past site operations.

Inorganics detected within the subsurface were similar to inorganics detected within the surface soils. The relatively low concentrations were within the station-wide background levels.

The subsurface soil at Site 1 has not been significantly impacted by site operations. There is no apparent source or discernable pattern of contamination within this media. The leaching of subsurface soil contaminants to groundwater is a potential contaminant migration pathway. Organic contaminants detected in groundwater at Site 1 have likely migrated through (or from) the subsurface soils. The analytical results from the subsurface soil samples collected during this investigation; however, indicates that this media is not currently acting as a source of groundwater degradation at Site 1.

Groundwater

This section addresses the extent of groundwater contamination at Site 1. Figure ES-1 illustrates the extent of organic contaminants in groundwater. Possible sources of groundwater contamination and potential migration of contamination are also evaluated.

During the Round Two RI shallow and a deep monitoring wells were installed within the shallow (Columbia) and deeper (Cornwallis Cave/Yorktown Eastover) aquifer at Site 1 to determine the horizontal and vertical extent of groundwater contamination.

Results of the Round Two RI indicated that the horizontal extent of VOC contamination (chlorinated solvents) detected in the Round One RI at Site 1 is limited to the western portion of the landfill near 1GW12. The highest concentrations of TCE and 1,2-dichloroethene were detected in 1GW20 at 90 µg/L and 52 µg/L, respectively. These concentrations were detected within the shallow Columbia aquifer.

Concentrations of inorganics in shallow groundwater were generally within the range of the station-wide levels for both total and dissolved fractions (with the exception of cadmium that exceeded the Federal MCLs at one location for both the total and dissolved fractions).

VOC contamination (chlorinated solvents) was also detected within the deeper monitoring wells installed within the Cornwallis Cave/Yorktown Eastover aquifer. Concentrations of TCE were greatest (360 µg/L) within the shallow portions of the aquifer just below the Cornwallis confining unit at 1GW12B. A groundwater sample collected within the deeper portions of the aquifer at 1GW12A showed a decrease of TCE concentrations (46B µg/L). The concentrations of TCE within this sample was qualified as a blank contaminant and the concentrations may be regarded as nondetect; however, it is presented here as a conservative estimate of the vertical extent of groundwater contamination.

Although concentrations of chromium and lead exceeded the Federal MCLs, the inorganic concentrations detected in the deep groundwater were generally within the range of the station-wide levels for both total and dissolved fractions.

The vertical extent of groundwater contamination appears to be limited to the upper portion of the Cornwallis Cave aquifer. The horizontal extent of groundwater contamination is limited to a small area in the southwest corner of the site. The data presented on these figures suggests that the lateral migration of shallow (Columbia) groundwater contaminants has been limited and that some vertical (Columbia to Cornwallis Cave) migration has occurred.

Groundwater flow at Site 1 is somewhat complicated. Static water level in the (shallow) Columbia aquifer (30 ft-msl) is much higher than the base surface water level of Indian Field Creek (5 ft-msl). As depicted on Figure ES-2, the Cornwallis Cave confining unit has been eroded away in the vicinity of the drainageway that separates Sites 1 and 3 (it has been completely eroded in the subsurface of Site 3). Groundwater in the Columbia aquifer flows toward this drainageway (south) and apparently discharges to the near-surface and migrates to Indian Field Creek through a form of overland flow that occurs just below the surface. This area where the Cornwallis Cave confining unit has been eroded may provide an avenue for vertical migration of contaminants from the Columbia aquifer to the Cornwallis Cave aquifer.

Static water levels in wells screened within the Cornwallis Cave/Yorktown Eastover aquifer (12 ft bgs) indicate a more straightforward flow of groundwater from Site 1 toward Indian Field Creek.

Surface Water

The Round Two RI surface water analytical results were consistent with the Round One RI results; VOCs, SVOCs, pesticides/PCBs and nitramines were not detected in the surface water. Cadmium and copper slightly exceeded the Station-wide levels and Federal and Commonwealth of Virginia ambient water quality criteria in all three samples.

The surface water within the study area has not been significantly impacted by operations at Sites 1 and 3. There is no apparent source or discernable pattern of contamination in this media.

Sediment

Relatively low concentrations of inorganics were detected within the samples. No organic contaminants were detected. Only the concentrations of cadmium and copper exceeded Station-wide background levels. Concentrations of arsenic, cadmium, and lead slightly exceeded sediment screening values. Only arsenic was detected in more than one sample at both sample intervals.

The sediment within the study area has not been significantly impacted by operations at Sites 1 and 3. There is no apparent source or discernable pattern of contamination in this media.

Site 3

Surface Soil

Following evaluation of data collected during the Round One RI, low concentrations SVOCs were identified as soil contaminants across Site 3, this is consistent with the analytical results of the Round Two sampling event. The concentrations of SVOCs (mainly PAHs) were detected within two samples. One sample (3SS10) had elevated concentrations of PAHs located at the eastern portion of the site. Sample 3SB08A-00 also located at the eastern portion of the site had similar compounds detected but at significantly lower concentrations. The SVOCs detected are possibly related to past disposal practices.

One PCB compound (aroclor-1260) was detected at low concentrations at 3SS11 collected down gradient of a debris pile and may be attributed to past site operations. Low concentrations of pesticides were detected in one sample (3SB08A-00) are consistent with historical use of Station-wide spraying, consistent with historical use of Station-wide spraying.

Inorganic concentrations slightly exceeded station-wide levels for arsenic and lead in one sample for each analyte.

Confirmation Sampling

The confirmatory surface soil samples collected around sample location 3SS10 (see Section 2.2.1.1 and Figure 2-1) indicated the presence of PAHs. The elevated concentrations of PAHs appears to be related to a "tar-like" substance observed during collection of the samples. These concentrations are limited to a small areal extent within the surficial (0- to 6-inches bgs) soil. In addition, the concentrations decrease by an order of magnitude in the subsurface sample 3SB10B (1.5 - to 2.0 ft bgs).

The surface soil at Site 3 has not been significantly impacted by site operations. With the exception of sample location 3SS10, there is no apparent source or discernable pattern of contamination within this media. The 3SS10 location may represent a "hot spot" of SVOC contamination, or it may be

the result of some sampling/analysis bias (e.g., a piece of plastic debris mixed in with the surface soil sample).

Subsurface Soil

Low to moderate levels of VOCs were detected at two locations 3SB15A (15- to 17-feet bgs) and 3TP02 (including the duplicate) from 8- to 9-feet bgs. VOCs were not detected in 3SB15A at the 23-to 25 foot interval.

Relatively low concentrations of SVOCs were detected at 3SB15A at 23- to 25 feet bgs and at 3TP02 at 7- to 8-feet bgs. Low levels of pesticides were also detected at these same locations and depths. These contaminants may be the result of past disposal practices at the landfill.

Inorganics detected within the subsurface were similar to inorganics detected within the surface soils. The relatively low concentrations were within the Station-wide background levels.

The subsurface soil at Site 3 has not been significantly impacted by site operations. There is no apparent source or discernable pattern of contamination within this media. The leaching of subsurface soil contaminants to groundwater is a potential contaminant migration pathway. Organic contaminants detected in groundwater at Site 3 may have migrated through (or from) the subsurface soils. The analytical results from the subsurface soil samples collected during this investigation; however, indicates that this media is not currently acting as a source of groundwater degradation at Site 3.

Groundwater

This section addresses the extent of groundwater contamination at Site 3. Figure ES-1 illustrates the extent of organic contaminants in groundwater. Possible sources of groundwater contamination and potential migration of contamination are also evaluated.

During the Round Two RI shallow and deep monitoring wells were installed within the aquifer at Site 3 to determine the horizontal and vertical extent of groundwater contamination.

Results of the Round Two RI were consistent with VOC contamination (chlorinated solvents) detected in the Round One RI. The highest concentrations of VOCs were detected at 3GW19 installed within the shallow portions of the Cornwallis Cave/Yorktown-Eastover aquifer with concentrations of vinyl chloride at 48 µg/L, 1,1-dichloroethene at 4 µg/L, 1,2-dichloroethene at 570 µg/L, and trichloroethene at 860 µg/L.

The groundwater samples collected at greater depths within this same aquifer showed a significant decrease of VOC concentrations. The highest levels were located at 3GW19A (adjacent to 3GW19) which had concentrations of 1,2-dichloroethene at 24 µg/L and trichloroethene at 24 µg/L.

Concentrations of total inorganics in groundwater were generally within the range of the Station-wide levels except at 3GW19A where chromium exceeded the Federal and the Commonwealth of Virginia MCLs at a concentration of 177 µg/L and lead exceeded the Federal MCL at a concentration of 22 µg/L.

The vertical extent of groundwater contamination at Site 3 appears to be limited to the upper portion of the Cornwallis Cave/Yorktown Eastover aquifer. There is a significant decrease in contaminant levels from shallow to deep portions of the aquifer. The horizontal extent of groundwater contamination, as depicted on Figure ES-1, covers the majority of the Site 3 area but is most pronounced (i.e., highest concentrations) to the north of the site.

Groundwater flow is generally toward Indian Field Creek, where groundwater discharge is likely (Figure ES-2). Surface water/sediment samples collected from Indian Field Creek during this investigation do not contain the organic contaminants that were detected in Site 3 groundwater. The data presented on these Figures (along with surface water/sediment data collected from Indian Field Creek) suggests that the lateral migration of groundwater contaminants has been limited and that some vertical migration has occurred.

HUMAN HEALTH RISK ASSESSMENT

This section summarizes the results of the baseline RA and identifies environmental media and COPCs which could potentially pose human health risks and/or effects. Potential carcinogenic and noncarcinogenic human health risks were estimated for human receptors under RME exposure

scenarios previously identified in Section 6.2.1. For each receptor, total risks were estimated by site for on-Station current trespassers, future residential receptors, and future construction workers. It should be noted that risks due to surface and subsurface soil were calculated by site, while risks due to groundwater were separated further by aquifer. Risks associated with surface water and sediment were estimated over both sites, and were summed with surface soil and groundwater risks for each site. Groundwater risks were also estimated for three individual well locations: 3GW19 and 1GW12B from the Cornwallis Cave/Yorktown-Eastover aquifer and 1GW20 from the Columbia aquifer. Risks associated with these individual well exposures were estimated from maximum detected concentrations. Groundwater risks were summed with the other three media for each site under future residential scenarios. Future construction workers were evaluated only for subsurface soil exposures for each site.

In addition, due to the conservative nature of the RME evaluation of future residential land use, residential risks were also evaluated under a set of exposure concentrations and assumptions that approximates CT. CT risks are represented in all residential risk characterization tables by the values presented in parentheses. The following paragraphs present the potential current and future exposure pathways and the subsequent potential total site risk to humans.

Current Potential Receptors

Potential current receptors to COPCs detected in environmental media at Sites 1 and 3 include:

- Adolescent on-Station trespassers (7-15 years old)
- Adult on-Station trespassers

The total incremental cancer risk (ICR) values for the current adult and adolescent on-Station trespassers at Sites 1 and 3 fall within the USEPA's generally acceptable target risk range of 1×10^{-06} to 1×10^{-04}. The target risk range represents the range of potential risks that USEPA generally to 1×10^{-04}. Hazard Index (HI) values for current potential human receptors in both Site 1 and Site 3 fall below 1.0, indicating that noncarcinogenic adverse human health risks will probably not occur subsequent to exposure.

Future Potential Receptors

Property use at Sites 1 and 3 will remain the same in the foreseeable future. Future residential development of these sites is highly unlikely given their location within an area encumbered by the explosive safety quantity distance (ESQD) arc, which prohibits its development as Station housing. However for the sake of conservatism, future residential land use and associated potential risks were evaluated for each area of concern. The potential human receptors evaluated under the future scenarios were:

- Future adult residents
- Future young child residents (1-6 years old)
- Future adult construction workers

As stated previously, due to the conservative nature of the risk assessment for residential land use, both reasonable maximum and central tendency scenarios were evaluated. Future residents were evaluated for exposures to all media. Construction workers were evaluated for only reasonable maximum subsurface soil exposures.

Total residential lifetime risks resulting from summing over adult and child risks for each site and potable source scenario, as well as the carcinogenic and noncarcinogenic risks to the future construction worker for both sites were evaluated. Risks calculated for the future construction worker for both sites were within acceptable levels. RME carcinogenic and noncarcinogenic residential risks exceed acceptable criteria for all scenarios. Under CT scenarios, all total carcinogenic risks for Site 3, in addition to total carcinogenic risk in one of the four potable source scenarios for Site 1, exceed USEPA acceptable risk criteria. Also, all HIs under the CT scenario exceed acceptable criteria except for one potable source scenario in Site 1. A discussion of the results for each of these scenarios is presented below.

Future Residents

It was assumed that future (adult and child) residents could potentially be exposed to COPCs in surface soil, groundwater, surface water, and sediment. Even though the future development of

groundwater for potable purposes is unlikely, given the availability of municipal water, potential potable exposure to COPCs in groundwater was evaluated for the sake of conservatism.

Total ICR values estimated for RME residential receptors exceeded the USEPA's target risk range of 1×10^{-06} to 1×10^{-04} in both Site 1 and Site 3. This was due primarily to the contaminants detected in the groundwater medium. Exceedences of the target risk range in Site 1 and Site 3 occurred based on the location of the groundwater receptor locations being considered. In Site 1, both the Columbia and Cornwallis Cave aquifers, including individual well locations, resulted in total risk levels exceeding USEPA's target risk range. In Site 3, exceedences by total ICRs occurred when evaluating the Cornwallis Cave aquifer and the designated well location. In the case of the Columbia aquifer groundwater receptor scenarios (averaged and location 1GW20) for Site 1, the individual ICRs fell within USEPA's acceptable risk range. In addition, the individual ICR for the Site 1 Cornwallis Cave well location 1GW12B was within the target risk range. In the case of the Cornwallis Cave aquifer groundwater receptor scenarios (averaged) for Sites 1 and 3 and 3GW19 for Site 3, the ICRs for adult and child exceeded the acceptable target risk range. For the groundwater scenarios in both sites, the presence of vinyl chloride (a potential degradation product of TCE) in the Cornwallis Cave aquifer contributed the most to exceedences of the target risk range. Also, vinyl chloride was not detected in Station background (Baker, 1995).

The ICR value estimated for RME residential receptors exposed to Site 3 surface soil exceeded the USEPA's target risk range of 1×10^{-06} to 1×10^{-04}. This is due primarily to the presence of benzo(a)pyrene. However, it should be noted that the maximum concentration of benzo(a)pyrene detected in Site 3 surface soil location 3SS10 was elevated by two orders of magnitude above the other PAH concentrations. Furthermore, the ICR value calculated under the CT residential scenario was within the target risk range. This could indicate a biased sample or a localized hot spot. In addition, PAHs were not detected in groundwater, surface water, or sediment.

HI values for future resident adults and children were greater than 1.0, suggesting that noncarcinogenic adverse health effects may occur subsequent to exposure. For the most part, elevated total HI values were due to contaminants detected in the two aquifers. Ingestion of and dermal contact with arsenic resulted in an unacceptable HI for surface soil (1.1) in Site 1 for the future child resident. At Site 3, ingestion of and dermal contact with manganese, arsenic, and antimony in surface soil resulted in an unacceptable HI for future child residents (1.3). It should be

noted that the individual pathway HIs for either site did not exceed unity. Site 1 surface soil concentrations of arsenic exceeded corresponding maximum detected Station background concentrations. Site 3 surface soil concentrations of manganese and antimony exceeded corresponding Station background, while arsenic did not.

In the Columbia aquifer groundwater receptor scenarios for Site 1 (averaged), dissolved manganese and TCE were the main contributors to the total HI value; whereas, in the Columbia aquifer groundwater receptor scenarios for 1GW20, TCE and 1,2-DCE were the main contributors to the total HI value. In the Cornwallis Cave aquifer groundwater receptor scenarios for Site 1 (averaged), TCE and 1,2-DCE were the main contributors to the total HI value. In the Cornwallis Cave aquifer groundwater scenario for 1GW12B, TCE is the primary contributor to the elevated HI. TCE and 1,2-DCE were not detected in Station shallow background (Baker, 1995). The maximum detected dissolved manganese concentration exceeded the maximum detected Station background concentration. In the Cornwallis Cave aquifer groundwater receptor scenarios for Site 3 (averaged) and 3GW19, TCE and 1,2-DCE were the main contributors to total HI values.

ECOLOGICAL RISK ASSESSMENT

The following subsections provided a brief overview of the potential ecological risks identified in this RA for each site.

Site 1 - Terrestrial Environment

Based on a screening of soil concentrations against flora/fauna toxicity values, the terrestrial environment at Site 1 is impacted by soil concentrations of aluminum, chromium, iron, lead, and vanadium. In addition, receptor models calculated for Site 1 demonstrated risks from surface soil concentrations of aluminum, chromium, copper, iron, lead, and vanadium. Site 1 surface soil concentrations of aluminum, chromium, iron, and vanadium were detected below normal background 95% UCL (background UCL) concentrations.

Site 1 surface soil concentrations of copper and lead were detected above background UCL concentrations. Surface soil concentrations of copper detected at Site 1 were below the surface soil screening level. Copper was included in the models because it was a surface water ECOC.

The terrestrial flora and fauna environment in Site 3 Proper is adversely influenced by soil concentrations of aluminum, antimony, chromium, iron, lead, manganese, mercury, thallium, vanadium, and zinc. Receptor models displayed risks from surface soil concentrations of aluminum, antimony, chromium, copper, iron, lead, and vanadium. The surface soil concentrations of aluminum and iron in Site 3 Proper were detected below background UCL concentrations. Whereas, concentrations of antimony, chromium, copper, lead, manganese, mercury, thallium, vanadium, and zinc were detected above background UCL concentrations. Although, copper was detected above background, the soil concentrations in Site 3 Proper were below screening levels. Copper was retained in the terrestrial models because it was a surface water ECOC.

The terrestrial flora and fauna community in the Soil AOC is adversely influenced by soil concentrations of SVOCs, aluminum, chromium, iron, lead, manganese, mercury, vanadium, and zinc. Receptor model species may be adversely impacted by surface soil concentrations of SVOCs, aluminum, chromium, copper, iron, lead, manganese, mercury, vanadium, and zinc. These compounds were detected above background concentrations, exceeded flora/fauna toxicity values, or generated risks in the terrestrial models.

Sites 1 and 3 - Aquatic Environment

The aquatic environment at Sites 1 and 3 is adversely affected by surface water concentrations of aluminum, copper, and iron. Aluminum and iron concentrations at Sites 1 and 3 were below background UCL concentrations. Copper exceeded the background UCL concentration. Surface water concentrations contribute to risks in the aquatic receptor models; however, sediment concentrations are the primary risk drivers.

Based on slight exceedances of benchmarks, sediment concentrations of cadmium, iron, and manganese potentially may adversely affect the benthic macroinvertebrate community at Sites 1 and 3. In addition, other aquatic receptors inhabiting Sites 1 and 3 may be adversely impacted by aluminum, copper, iron, and lead, as indicated by the receptor models. It is noted that sediment concentrations of aluminum and manganese are below background UCL concentrations. It is noted that copper was detected below sediment screening levels, but was retained in the receptor models

because it is a surface water ECOC. Sediment concentrations of iron and lead were detected above background UCL concentrations.

CONCLUSIONS

The horizontal and vertical extent of groundwater VOC contamination within the shallow and deep aquifers at both sites has been defined.

The analytical data suggests that upgradient sources of the VOC contamination within the landfill at Site 1 does not exist and the presence of DNAPL was not observed within the subsurface soil obtained during monitoring well installation.

There were no human health or ecological risks associated with the surface or subsurface soils at Sites 1 or 3 with the exception of the SVOC AOC at Site 3.

The results of the ecological risk assessment indicate a minimal threat to the environment.

PAHs (mainly benzo(a)pyrene) are driving the human health risk for the current adult and adolescent on-Station trespassers resulting from exposure to the SVOC AOC at Site 3.

Results of the human health risk assessment indicate noncarcinogenic and carcinogenic risks for the future residential scenario as a result of exposure to the shallow (Columbia) aquifer and the deeper (Cornwallis Cave/Yorktown-Eastover) aquifer.

The groundwater (shallow and deep) at WPNSTA Yorktown is not currently being used and will not be used in the future as a potable source given the mission of the station. The poor water quality is a result of hardness, high pH, and low yield that reflects the characteristics of a Class III aquifer which do not adhere to the water quality criteria of a drinking water aquifer. In addition, Sites 1 and 3 are within the WPNSTA Yorktown safety quantity distance (ESQD) arc (areas restricted to ordnance-related facilities) and as such, residential usage of the sites is prohibited.

Results of the RI and Baseline Risk Assessment dictate the following:

- No further action is required at Sites 1 and 3 with respect to groundwater (restrictions on the use of groundwater as a potable source will be applied.

- No further action is required at Sites 1 and 3 with respect to soil after a limited removal of surface soil at the SVOC "hot spot" at Site 3. The limits of the removal action will be determined by confirming the absence of PAHs through field test kit analysis and the collection of confirmatory soil samples (surface and shallow subsurface;< 3-ft bgs) sent to a laboratory for SVOC analysis.

FIGURES

318725WP

SITE 1

SITE 3

1GW13 (ND)

1GW17 (ND)

1GW05 (ND)

1GW14 (ND)

1GW19 (4J)

1GW18 (ND)

1GW12 (104B)

1GW20 (T42)

1GW04 (ND)

3GW19 (1482)

3GW08 (10)

3GW07 (3J)

3GW15 (110)

3GW08 (3J)

3GW18 (ND)

11GW11 (ND)

WOODS

DIRT ROAD

DIRT MOUND

POND

DEBRIS AREA

INDIAN FIELD CREEK

EDGE OF WATER

MAG. BLDG. 266

MAG. BLDG. 267

GATE

100

500

1,000

180 0 90 180

1 inch = 180 ft.

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NOTE: CONCENTRATIONS QUALIFIED WITH A "B" ARE NON-DETECT ACCORDING TO EPA REGULATIONS, BUT ARE PRESENTED ON FIGURES TO DEPICT THE MOST CONSERVATIVE SCENARIO.

LEGEND

- EDGE OF WATER
- TREELINE
- EDGE OF PAVEMENT
- BUILDING
- WETLANDS
- DEBRIS AREA
- REMEDIAL INVESTIGATION SITE
- 1GW11 – MONITORING WELL LOCATION
- (110) – TOTAL VOC CONCENTRATIONS IN ug/L
- 1,000 – ESTIMATED VOC CONCENTRATION CONTOUR IN ug/L

SOURCE: PHR & A, AUGUST 1995.

FIGURE ES-1

HORIZONTAL EXTENT OF TOTAL VOCs IN THE COLUMBIA AQUIFER (SITE 1) AND THE CORNWALLIS CAVE/YORKTOWN-EASTOVER AQUIFER (SITE 3)

NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

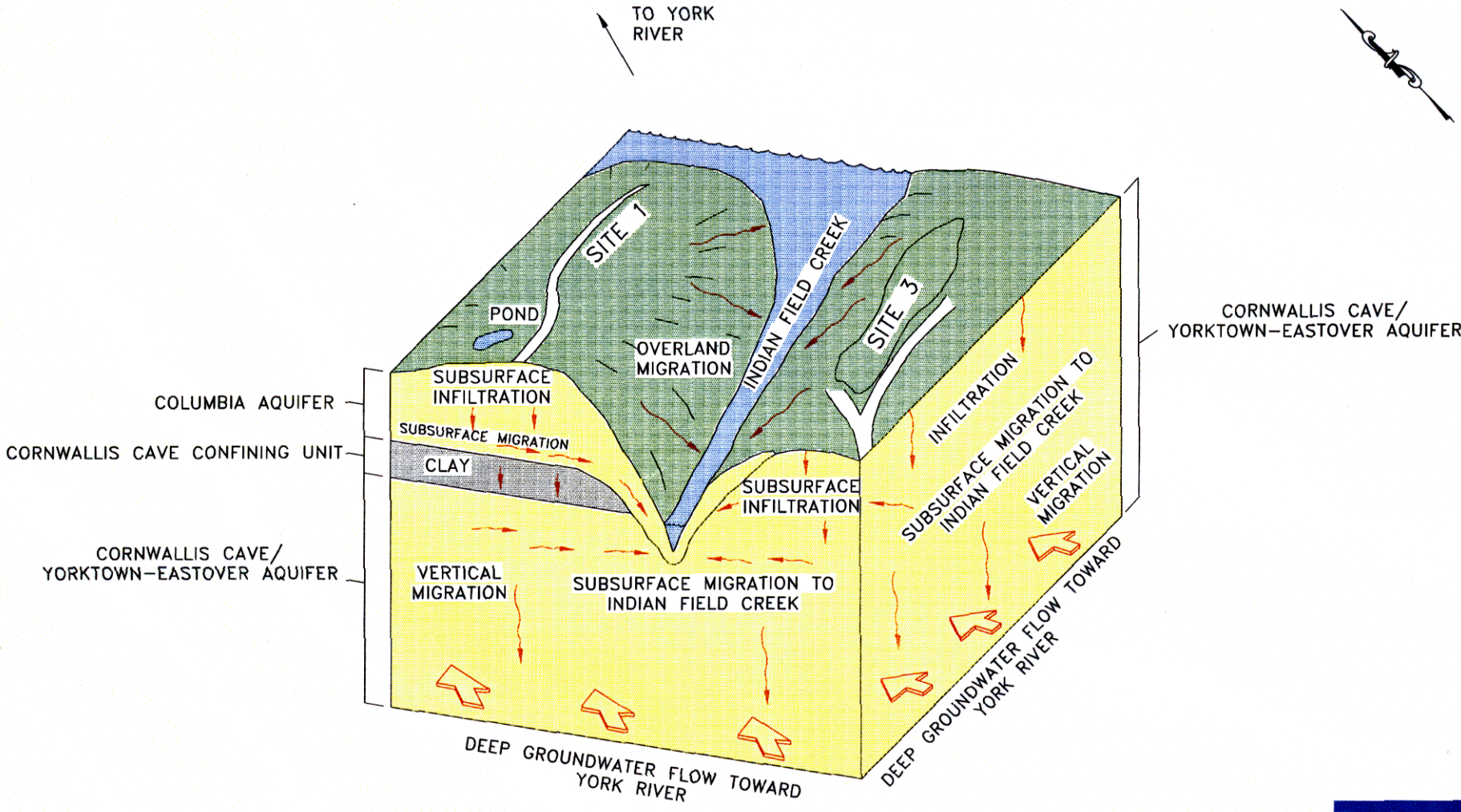

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FIGURE ES–2
SCHEMATIC SITE MODEL
SITES 1 AND 3

NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

N.T.S.

318507RI

1.0 INTRODUCTION

This report presents the results of the Round Two Remedial Investigation (RI) completed for Sites 1 (Dudley Road Landfill) and 3 (Group 16 Magazines Landfill) at the U.S. Naval Weapons Station Yorktown (WPNSTA Yorktown), Yorktown, Virginia (Figure 1-1). This RI Report has been prepared by Baker Environmental, Inc. (Baker) under the Department of the Navy's (DoN's) Comprehensive Long-Term Environmental Action Navy (CLEAN) contract administered by the Naval Facilities Engineering Command, Atlantic Division (LANTDIV).

This RI Report has been prepared in accordance with the WPNSTA Yorktown Federal Facility Agreement (FFA), the Yorktown Master Work Plans (Baker, 1994a), and applicable Federal, Commonwealth, and local regulations. Details of the Round Two RI Scope of Work at Sites 1 and 3 are contained in the Site-Specific Work Plan for Sites 1 and 3 (Baker, 1996a). In addition, the United States Environmental Protection Agency's (USEPA's) document, Guidance for Conducting Remedial Investigations and Feasibility Studies Under Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (USEPA, 1988) has been used as guidance for preparing this report. The RI Report has been prepared using available information from the previous investigations, such as the Round One RI effort (Baker/Weston, 1993a) and from data collected during the Round Two RI, which was conducted during January and February 1996.

The objectives of this RI are: (1) to conduct a Round Two remedial investigation based on the results of the Round One RI; (2) to assess the nature and extent of contamination at each site and/or to address data gaps observed after the Round One RI preventing an adequate understanding of site conditions; and (3) to assess potential human health and ecological risks associated with any contamination at Sites 1 or 3 and identify any potential remaining data gaps.

This document is organized into seven additional sections. Section 2.0 describes the field activities conducted during the Round Two RI at Sites 1 and 3. This section describes the purpose of the study of individual media, sampling procedures, and sampling locations for all media. Figures are included to show sampling locations. This section also discusses quality control (QC) conducted during the sampling and the management of the investigation derived waste (IDW).

Section 3.0 presents the physical features of Sites 1 and 3. This section discusses the general physiography (physical geography, meteorology, surface water hydrology), geology, soil, hydrogeology, and land use and demography.

Section 4.0 presents the nature and extent of contamination found at Sites 1 and 3. This section presents the results of the field sampling activities conducted as part of this RI. The results are presented by media: surface and subsurface soil, groundwater, surface water, sediment, and biota. This section also discusses the potential sources of contaminants detected during the sampling activities.

Section 5.0 characterizes the fate and transport of the contaminants found at Sites 1 and 3. This characterization includes: potential routes of contaminant migration, contaminant persistence, and contaminant migration.

Sections 6.0 and 7.0 contain the baseline risk assessments (RAs) conducted for the sites. The baseline human health RA (Section 6.0) contains a human health evaluation and an environmental evaluation. An ecological RA is included in Section 7.0.

A summary and conclusions are presented in Section 8.0. This section summarizes the nature and extent of contamination, contaminant fate and transport, and potential human health and ecological impacts associated with the site.

1.1 Site History and Results of Previous Investigations

The information in this section has been drawn from the Site Management Plan (Baker, 1996b), the Round One RI Report (Baker/Weston, 1993a), the Summary of Background Constituent Concentrations and Characterizations of the Biotic Community for the York River Drainage Basin (Baker, 1995), and Final Master Project Plans (Baker, 1994a). Additional information was included from a confirmation sampling event conducted by Baker on July 12, 1995.

1.2 Sites 1 and 3-Description and History

Fifteen sites requiring RI/Feasibility Study (FS) activities are identified in the Fiscal Year 1996-1997 Site management Plan (SMP) for WPNSTA Yorktown (Baker, 1996b) The location of these sites including Site 1 and 3 within the Station are presented on Figure 1-2. Figure 1-3 presents an aerial photograph of the sites and Figure 1-4 shows a more detailed view of the sites. The following subsections provide an overall description of the Station and site-specific information for Sites 1 and 3.

1.2.1 Site 1 - Dudley Road Landfill

Site 1 is a 6-acre area located just north of the headwaters of Indian Field Creek (Figure 1-3). The landfill was in use from approximately 1965 to 1979 for general disposal, with one area reportedly used for disposal of plastic lens grinding waste until 1983. The site was originally used for sand mining. There are two unfilled sand borrow pits at the site. One is located within the eastern portion of the site quadrant and is vegetated with loblolly pine. The second unfilled borrow pit is within the southwest portion of the site and accumulates surface water runoff. The water within this unfilled borrow pit fluctuates greatly throughout the year from a few inches to approximately 2-feet deep. Seasonal ponding also occurs in the southeastern section of the site. Wastes reportedly disposed within the depression created by sand mining include asbestos insulation from steam piping; oil, grease, paint, and solvent containers; nitramine-contaminated carbon; household appliances; scrap metal banding; construction rubble; plastic lens grinding wastes; tree limbs; lumber; packaging wastes; electrical wires; and waste oil. The landfill received an estimated 255 tons of waste during the time in which the site was in use. The landfill is covered by approximately two feet of soil and the abandoned sand reclamation area is covered by 8 feet of soil (Final Master Project Plans, Baker, 1994a).

On January 12, 1979 the VADEQ performed an inspection of the site. The landfill did not meet the requirements for a permitted landfill by the Virginia Department of Health governing the disposal of solid waste. The deficiencies were corrected and the landfill received approved waste until 1985 when the facility was closed. Another inspection conducted of the closed disposal facility on August 29, 1995 (by VADEQ), found deficiencies (subsidence and ponding water) within the

landfill cover. The station replied that this noncompliance item will be addressed under the IR program.

1.2.2 Site 3 - Group 16 Magazines Landfill

Site 3 is a 2-acre area located behind the Group 16 Magazines, just south of Site 1 (separated from Site 1 by a ravine), along the headwaters of Indian Field Creek (Figure 1-4). The landfill is named for its proximity to the Group 16 Magazines. The history of this landfill is unrelated to operations at the magazines. The landfill area was reportedly in use from 1940 to 1970. The site was originally used for sand mining. Wastes that were disposed within the depression (unfilled borrow pit) created by sand mining include solvents, sludge from boiler cleaning operations, grease trap wastes, Imhoff tank skimmings containing oil and grease, and animal carcasses. This landfill received an estimated 90 tons of waste during the time in which the site was in use. Currently, most of the site, which is overgrown with trees, is covered by approximately two feet of soil with some scattered surface debris (Final Master Project Plans, Baker, 1994a).

1.3 Results of Previous Investigations

Previous investigation reports completed through the IRP at WPNSTA Yorktown include the following:

- Initial Assessment Study (IAS) (C. C. Johnson & Associates, Inc. and CH2M Hill, 1984)
- Confirmation Study Rounds One and Two Reports (Dames and Moore, 1986 and Dames and Moore, 1988)
- RI Interim Report (Versar, 1991)
- Focused Biological Sampling and Preliminary Risk Evaluation Report (Baker, 1993b)
- Round One RI Report (Baker/Weston, 1993a)

- Habitat Evaluation Report (Baker, 1994b)

Additionally, a confirmation sample from one groundwater monitoring well was collected on July 12, 1995 (Baker) and analyzed to confirm results from the Round One RI report. These reports have been generated in conjunction with the continuing development of the DoD IRP. Summaries of previous investigations are provided in the following subsections.

1.3.1 Initial Assessment Study

The purpose of the IAS (C. C. Johnson & Associates, Inc. and CH2M Hill, July 1984) was to identify and assess sites posing a potential threat to human health and/or the environment due to contamination from past operations. A total of 19 potentially contaminated sites were identified based on information from historical records, aerial photographs, field inspections, and personnel interviews. Each site was evaluated for the type of contamination, migration pathways, and pollutant receptors. The IAS concluded that 15 of the 19 sites, including Sites 1 and 3, were of sufficient threat to human health or the environment to warrant Confirmation Studies (CS).

1.3.2 Confirmation Study and RI Interim Report

Two rounds of data were obtained during the CS effort. The first round of sampling and analysis was documented in the "Confirmation Study Step IA (Verification), Round One" (Dames & Moore, 1986). The results of the second round of sampling and comparisons with appropriate regulatory standards were presented in the Confirmation Study Step IA (Verification, Round Two" [Dames & Moore, 1988]). The results of these field efforts were combined and summarized in the Draft RI Interim Report (Dames & Moore, 1989). This report was subsequently revised by Versar, Inc. (Versar) in 1991 to incorporate comments from the former Technical Review Committee (TRC); now called a Restoration Advisory Board (RAB). The revised report is referred to as the RI Interim Report (Versar, 1991). The RI Interim Report recommended that further RI activities be completed at 14 of the 15 sites; including Sites 1 and 3.

Monitoring wells installed at Sites 1 and 3 during the CS are still in existence and have been incorporated into the groundwater monitoring network for the Round Two RI at these sites. These monitoring wells include: 1GW04, 1GW05, 3GW06, 3GW07, and 3GW08.

1.3.3 Biological Sampling and Risk Evaluation Report

The Focused Biological Sampling and Preliminary Risk Evaluation Report (Baker/Weston, 1993b) summarized the results of a limited biological tissue, surface water, and sediment sampling effort conducted in October 1992. The primary objective of the sampling program was to evaluate the potential human health risk associated with consumption of fish and shellfish taken from select waters within WPNSTA Yorktown, including Indian Field Creek.

1.3.4 Round One Remedial Investigation

The results of the Round One RI (Baker/Weston, 1993a) indicated that further investigation was needed at all sites that were studied to better define the nature and extent of contamination associated with each site. Data indicate that surface soil, subsurface soil, groundwater, surface water, and sediment have been potentially impacted by past site activities. In this report, references are made to "control samples", which are background samples collected during the Round One RI. These should not be confused with the background samples collected as part of the comprehensive station-wide background investigation conducted in 1994 (Baker, 1995b). The results of the Round One RI at Sites 1 and 3 are presented below.

1.3.4.1 Site 1 Round One RI

The data from the Round One RI is summarized for Site 1 by media in the following subsections.

Surface and Subsurface Soil Sampling Results

During the Round One RI, a total of 13 soil samples (ten surface and three subsurface soil) were collected at Site 1. The surface soil samples were collected from 0- to 2-feet below ground surface (bgs). Sample locations are presented in Figure 1-5. The samples were analyzed for volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), target analyte list (TAL)

inorganics, explosives, and pH. Selected (organic) analytical results for the soil samples are presented on Figure 1-6 (only detected compounds illustrated). No VOCs were detected in surface soil samples except for a low concentration of toluene (a possible laboratory contaminant) in surface soil sample 1S02-001. Although toluene was not detected in the blanks, this finding was attributed to laboratory contamination. Several SVOCs in surface soil samples were detected at low concentrations, as illustrated in Figure 1-6. The relatively high concentration of bis(2-ethylhexyl)phthalate at 1S02-001 may be attributable to the plastic lens-grinding wastes reportedly disposed at Site 1. However, phthalate esters are common laboratory and sampling contaminants. Inorganic concentrations in surface soils were generally close to the Round One RI control samples with the exception of one elevated level of lead (Table 1-1).

In the subsurface soil samples, no VOCs were detected except for methylene chloride, a common laboratory contaminant, at very low concentrations in three borings. SVOCs were detected in one sample (1SB12) at low to moderate concentrations and were similar to those found in a nearby shallow soil sample, 1S02-001 (see above). Inorganic concentrations in subsurface soils were generally similar to the Round One RI control samples except for a slight exceedence of zinc in one boring (Table 1-1).

Groundwater Sampling Results

Four groundwater monitoring wells were installed during this investigation (1GW12, 1GW13, 1GW14, and 1GW17). They were sampled along with the two existing wells (1GW04 and 1GW05) for a total of six sampling stations (Figure 1-5). The groundwater samples were analyzed for VOCs, SVOCs, nitrates, explosives, and inorganics (total and dissolved). VOCs were detected at only one location, 1GW12 (Figure 1-7). Concentrations of 1,2-dichloroethene (DCE), trichloroethene (TCE), and tetrachloroethene (PCE) were above the Maximum Contaminant Levels (MCLs). No SVOCs were detected except for diethylphthalate (1J µg/L) in 1GW12. Diethylphthalate is a common sampling and laboratory contaminant. Explosives were not detected within the Site 1 groundwater samples. As shown on Table 1-2, inorganics and nitrates were detected above criteria in several samples. Antimony, arsenic, cadmium, and nickel were detected in the total metals samples at Site 1, but were not detected in the Round One control samples.

Surface Water Sampling Results

As shown on Figure 1-5, a total of seven surface water samples (six locations, with one location having a shallow and deep sample) were collected at Site 1 and analyzed for VOCs, SVOCs, inorganics (total and dissolved), explosives, hardness, pH, and TOC. Analysis indicated that no VOCs, SVOCs, or explosives were detected in any surface water samples. Total and dissolved metals concentrations were generally similar to the Round One RI control samples with few exceptions. Table 1-3 lists the inorganic analytical results.

Sediment Sampling Results

A total of sixteen sediment samples were collected at Site 1 (Figure 1-5). Two sediment samples (0- to 4-inches bgs and 4- to 8-inches bgs) were taken at each of eight (1SD05 through 1SD12) sampling stations. The samples were analyzed for VOCs, SVOCs, metals, explosives, pH, and TOC. Analytical results are presented on Figure 1-8. Several metals were detected at 1SD05, 1SD06, and 1SD07 above the concentrations in the Round One RI control samples. Table 1-4 presents inorganic concentrations for sediment samples.

Round One RI Investigation Summary for Site 1

This data indicates that activities at Site 1 have not had a significant impact to the groundwater at Site 1 except for the high concentrations of VOCs localized in 1GW12 (specifically TCE) and limited inorganics detections. The Round Two sampling effort focuses, in part, on determining the vertical and horizontal extent of the VOC contamination in groundwater and also confirming that other media are not affected by the VOCs. Surface soils at Site 1 contain low concentrations of SVOC compounds, and an elevated concentration of lead at one location. Aside from methylene chloride (possible lab contaminant), no VOCs were detected in subsurface soils and only limited SVOCs and inorganics were detected. No VOCs, SVOCs or explosives were detected in any surface water samples. Concentrations of inorganics in Site 1 sediment samples were similar to Round One control sediment samples. The sediment samples collected downstream of Site 1 contain contaminants and elevated inorganics concentrations that were not detected in the samples collected closer to the site.

1.3.4.2 Site 3 Round One RI Investigation

The data from the Round One RI is summarized for Site 3 by media in the following subsections.

Surface and Subsurface Soil Sampling Results

Three surface and four subsurface (two each from two borings) soil samples were collected for a total of seven soil samples (Figure 1-5). The samples were analyzed for VOCs, SVOCs, and inorganics. No VOCs were detected in surface soil samples except for toluene in 3S03. Toluene was not detected in the duplicate sample collected at this location. Low concentrations of SVOCs were detected in all three surface soil samples as shown on Figure 1-6. Inorganic concentrations were at levels generally similar to the Round One RI control samples with few variances (lead, vanadium, and cadmium were detected above concentrations of the control samples). Cyanide was not detected in any surface soil sample. Table 1-1 presents inorganic concentrations for surface and subsurface soil.

In subsurface soil samples limited VOCs were detected at low concentrations, including methylene chloride, carbon disulfide, and acetone (possible laboratory contaminants). No SVOCs were detected in any of the subsurface soil samples. Inorganic concentrations were generally similar to the Round One RI control samples with few variances including calcium, magnesium, sodium, and vanadium (Table 1-1).

Groundwater Sampling Results

Two groundwater monitoring wells were installed during the field effort (3GW15 and 3GW18). These two wells, along with three existing wells (3GW06, 3GW07, and 3GW08) were sampled for VOCs, SVOCs, nitrates, and inorganics (total and dissolved) (Figure 1-5). TCE was detected in four monitoring wells, as shown on Figure 1-7. The concentrations of TCE exceed the MCL at three of these locations. 3GW15 had the highest level of TCE detected and also contained 1,2-DCE which is a common degradation product of TCE. No SVOCs were detected except phenanthrene at 3GW18 as shown on Figure 1-7. Elevated concentrations of inorganics including lead, manganese, and zinc were detected in the total phase (Table 1-2).

Surface Water Sampling Results

Two surface water samples were collected and analyzed for VOCs, SVOCs, and inorganics (total and dissolved) (Figure 1-5). No VOCs or SVOCs were detected in any surface water samples. Table 1-3 presents the inorganics analytical results.

Sediment Sampling Results

A total of four sediment samples (two at two locations) were collected and analyzed (Figure 1-5). The samples were analyzed for VOCs, SVOCs, inorganics and TOC. The results are presented on Figure 1-8. Limited VOCs and SVOCs were detected (primarily possible laboratory contaminants). Inorganic concentrations were generally similar to the Round One RI control samples (Table 1-4).

Round One RI Investigation Summary for Site 3

The Round One RI data results indicate that surface soils do not appear to be adversely impacted by the landfill while subsurface soil sample results indicate the presence of low levels of VOCs and inorganics. The landfill activities at Site 3 may have affected the groundwater based on the presence of TCE and possibly inorganics contamination. Most of the inorganics detected were in the total rather than the dissolved sample and, thus, these inorganics appear to be due to the suspended sediments and are not transported by groundwater. The surface water and sediment concentrations were above the Round One RI control levels but below the respective standards.

1.3.5 Habitat Evaluation Results

The Habitat Evaluation results (Baker, 1994b) are presented in two subsections, aquatic habitats which discusses the stream areas, and terrestrial habitats which discusses the land areas. The areas discussed are presented on Figure 1-4. Sites 1 and 3 are located in the watershed of Indian Field Creek.

1.3.5.1 Site 1 Habitat Evaluation Results

The results of the aquatic and terrestrial habitat evaluations for Site 1 are presented below.

Aquatic Habitats

The Commonwealth of Virginia has classified surface waterways according to potential uses based on water quality. The streams found on the main section of WPNSTA Yorktown are in Section 1 of the York River Basin and are classified as Class 2 waters. Section 1 includes the York River and the tidal portions of its tributaries from Goodwin Neck and Sandy Point upstream to Thorofare Creek and Little Salem Creek near West Point, Virginia. Class 2 water bodies have fish-sustaining qualities, but are lacking in aesthetic quality, productivity, or in some structural characteristic. The water body maintains good water quality, temperature, and summer flow; adjacent land is not extensively developed. The surface waterways in the main Station area are tidal and brackish; therefore, the water is not potable. However, these estuarine areas are highly productive for the development of aquatic communities and are potentially sensitive to manmade contaminants. These surface waters are subject to the VDEQ Water Division's surface water quality criteria standards (Baker/Weston, 1993b).

No freshwater streams are within or adjacent to Site 1. However, one unfilled sand borrow pit was identified in the western section of the site. The pond appears to be a depression composed of impervious material that retained surface water runoff during storm events. The pond is a source of drinking water for wildlife and provided habitat for frogs and other amphibians. Pond depth fluctuates considerably (few inches to approximately 2-feet deep), as evidenced by floodlines around tree trunks, water stained leaves, surface roots, and dry, intermittent channels with outlets above the present pond water surface. Plants identified in the emergent wetland included great bulrush, woolgrass, rushes, and small spike rush. Black willow and crack willow were present in the shrub wetland.

Terrestrial Habitats

The terrestrial environment in the vicinity of Site 1 was recorded as one of the most diverse of the eight sites in the habitat report. Birds were particularly plentiful, and amphibians, reptiles, and mammals were also numerous. The site includes three types of terrestrial habitats including an open field with a small pond, a scrub/mixed forest present along the edges of the open area, and an upland forest between the old landfill and the marsh.

The open field was dominated by a mixture of grasses and herbaceous perennial and annual plants. Overall, the plants were diverse and well mixed. Several species of trees and shrubs were present as scattered specimens across the open field. The pond, which was at a seasonal low during the field study, was ringed by saplings and shrubs.

Trees dominated the scrub shrub/mixed forest along the edges of the open field. Several planted areas of loblolly pine were present in the area and were also growing in the mixed forest area. Seedling and sapling trees, grasses, and herbaceous field plants were present in the understory of this area.

Upland forest was present as a narrow band between the former landfill and the marsh along Indian Field Creek. The understory in the upland forest was sparse and includes patches of blueberry, partridge, and spotted wintergreen. Flocks of birds were observed feeding on the site, particularly on the fruits of the autumn olive shrubs. Birds also seemed to be attracted to the small pond at the site. Most of the birds were classified as resident or breeding birds.

Two neotropical migrants were also identified during the field study, which coincided with fall migration. Several other migrating warblers were observed in small flocks. Several box turtles were found on the site and excavated turtle eggs were also present. White-tailed deer were also observed. Eastern cotton tail rabbits appeared to be common and signs of squirrels, raccoons, and groundhog were also noted.

1.3.5.2 Site 3 Habitat Evaluation Results

The results of the aquatic and terrestrial habitat evaluations for Site 3 are presented below.

Aquatic Habitats

Site 3 was similar to Site 1 in that there were no freshwater drainage channels (intermittent or perennial) identified on site. In addition, no other sources of freshwater were identified on the site. Site 3 is situated immediately adjacent to Indian Field Creek, and southeast of Site 1, with habitats similar to those associated with tidally influenced streams.

Terrestrial Habitats

Three general terrestrial habitats were present at Site 3. These included a mixed deciduous forest over most of the disposal area, a small open area dominated by herbaceous plants, and mature upland forest along the edges of the disposal area and the creek. The mixed deciduous forest in the disturbed area was dominated by trees that are relatively young. The understory in this mixed forest was well vegetated and included seedling trees, vines, shrubs, ferns, grasses, and herbs.

A portion of the disturbed area was not forested; in this area grasses and perennial and annual herbaceous plants were dominant, although seedling trees were also present. The most common seedlings were sweet gum, white oak, hickory, red cedar, and loblolly pine.

Mature upland forest was present beyond the disturbed areas and between the former landfill and Indian Field Creek. Trees were clearly dominant in this upland forest and included beech, tulip poplar, loblolly pine, dogwood, hickory, and ironwood. The understory was very sparse and generally was limited to seedling trees and scattered shrubs or mountain laurel.

Five relatively common species of birds were observed at Site 3, including robin, Carolina wren, blue jay, acadian flycatcher, and black-capped chickadee. One reptile, a five-lined skink, was observed at the Site 3 mixed forest. Signs of white-tailed deer and squirrels were also noted.

1.3.6 Confirmation Sampling

On July 12, 1995, a groundwater sample was collected from monitoring well 1GW12 at Site 1. The sample was submitted to the laboratory for analysis of VOCs to confirm the elevated level of TCE (18,000 µg/L) at this well presented in the Round One RI report. The sample was analyzed and TCE was detected at 3,900 µg/L, along with cis-1,2-dichloroethene at 520 µg/L. This information has aided with the approach to the work plan. The sample data received from the laboratory is provided in Appendix 1A.

1.4 References

Baker Environmental, Inc. 1996a. Final Work Plan for Sites 1 and 3, Naval Weapons Station Yorktown, Yorktown, Virginia. February 1996.

Baker Environmental, Inc. 1996b. Final Site Management Plan for Fiscal Years 1996-1997, Naval Weapons Station Yorktown, Yorktown, Virginia. February 1995.

Baker Environmental, Inc. 1995. Draft Summary of Background Constituent Concentrations and Characterization of the Biotic Concentration from the York River Drainage Basin, Naval Weapons Station Yorktown, Yorktown, Virginia. April 1995.

Baker Environmental, Inc. 1994a. Final Master Project Plans, Naval Weapons Station Yorktown, Yorktown, Virginia. June 1994.

Baker Environmental, Inc. 1994b. Final Habitat Evaluation Report, Sites 1, 3, 4, 6, 7, 12, 16, and 21, Naval Weapons Station, Yorktown, Virginia. June 1994.

Baker Environmental, Inc. and Roy F. Weston, Inc. 1993a. Final Round One Remedial Investigation Report for Sites 1-9, 11, 12, 16-19, and 21, Naval Weapons Station, Yorktown, Virginia. July 1993.

Baker Environmental, Inc. 1993b. Focused Biological Sampling and Preliminary Risk Evaluation Report, Naval Weapons Station, Yorktown, Yorktown, Virginia. July 1993.

C. C. Johnson & Associates, Inc., and CH2M Hill. 1984. Initial Assessment Study of Naval Weapons Station, Yorktown, Virginia. July 1984.

Dames and Moore. 1989. Draft Remedial Investigation Interim Report. February, 1989.

Dames and Moore. 1988. Confirmation Study Step 1A (Verification), Round Two, Naval Weapons Station, Yorktown, Virginia.

Dames and Moore. 1986. Confirmation Study Step 1A (Verification), Round One, Naval Weapons Station, Yorktown, Virginia.

Versar. 1991. Remedial Investigation Interim Report, Naval Weapons Station, Yorktown, Virginia.

TABLES

Round One Inorganic Concentrations in Surface and Subsurface Soil (mg/kg)
Table 1-1

SITE ID	1S01-001	1S02-001	1S03-001	1S04-001	1S05-001	1S06-001	1SB12-001	1SB12-002	1SB13-001
ANALYTE									
Aluminum	2130.000 J	1920.000 J	1890.000 J	4220.000 J	3460.000 J	2510.000 J	3280	1760	3550
Antimony	9.160 UJ	9.500 UJ	9.100 UJ	10.200 UJ	10.500 UJ	9.450 UJ	8.040 UJ	7.870 UJ	9.650 U
Arsenic	1.400 J	1.700 J	1.100 J	1.700 J	6.700 J *	2.100 J *	24.3 *	3.7	1.6 *
Barium	11.6	9.9	7.5	16.4	14	20.1	21.8	7.4	21.2
Beryllium	0.210 U	0.220 U	0.210 U	0.230 U	0.36	0.210 U	0.220 UJ	0.220 UJ	0.35
Cadmium	0.830 UJ	0.860 UJ	0.830 UJ	0.930 UJ	0.960 UJ	0.860 UJ	0.890 U	0.880 U	0.880 U
Calcium	202.000 J	342.000 J	32.410 J	694.000 J *	14900.000 J *	491.000 J	774	224	114
Chromium	2.7	4.7	3.2	9.1	8.3	5.5	5	4.1	4.2
Cobalt	1.250 U	1.300 U	1.240 U	1.390 U	1.9	1.290 U	3.8	1.530 U	1.8
Copper	1.6	1.9	2.4	2.3	3.6	5.9 *	4.5 *	2	1.1
Iron	2630.000 J	3670.000 J	3210.000 J	10400.000 J	7220.000 J	4380.000 J	5240	4460	4640
Lead	3.1	5	4.3	12.6	7.2	21.4 *	8.9	3.6	3.7
Magnesium	81.1	123	81.5	342	539 *	135	213	132	215
Manganese	14.300 J	18.800 J	12.100 J	81.200 J	33.300 J	36.600 J	127	22.4	39.3
Mercury	0.050 U	0.06	0.050 U	0.060 U	0.060 U	0.16	0.060 U	0.060 U	0.050 R
Nickel	3.750 U	3.890 U	3.720 U	4.180 U	4.310 U	3.870 U	4.020 U	3.940 U	3.950 U
Potassium	202.000 U	210.000 U	201.000 U	225.000 U	395	208.000 U	200.000 U	196.000 U	326
Selenium	0.420 UJ	0.430 UJ	0.400 UJ	0.460 UJ	4.710 UJ	0.440 UJ	0.440 UJ	0.430 U	0.440 UJ
Silver	1.250R	1.300 R	1.240 R	1.390 R	1.440 R	1.290 R	1.790 U	1.750 U	1.320 U
Sodium	10.600 UJ	11.000 UJ	10.500 UJ	19.900 J	117.000 J	11.000 UJ	26.100 U	25.600 U	26.5
Thallium	0.420 U	0.430 U	0.400 U	0.460 U	0.470 UJ	0.440 U	0.440 U	0.430 U	0.440 U
Vanadium	2.9	4.4	4.1	16.9	7.3	6.4	5.5	3.5	6.9
Zinc	2.1	15.3	4	9	17.7	29.3 *	17.5	96.4	5.400 J

Round One Inorganic Concentrations in Surface and Subsurface Soil (mg/kg)
Table 1-1 (Continued)

SITE ID	1SB13-002	1SB14-001	1SB14-002	1SB17-001	3S01-001	3S02-001	3S03-001	3S03-101	3SB15-001
ANALYTE									
Aluminum	2130	2050	2090	5240	3390.000 J	4240.000 J	2980.000 J	3920.000 J	1230
Antimony	9.310 UJ	7.670 UJ	7.380 UJ	8.000 UJ	9.950 UJ	9.910 UJ	10.000 UJ	10.600 UJ	7.390 UJ
Arsenic	0.8	0.81	0.66	1.8 *	5.200 J *	1.700 J	1.900 J	1.900 J	2.3 *
Barium	7.8	14	9.4	14.7	17.7	16.2	17.3	17.4	18.4
Beryllium	0.210 U	0.210 UJ	0.200 UJ	0.220 UJ	0.41	0.83 *	0.48	0.65	0.200 U
Cadmium	0.850 U	0.850 U	0.820 U	0.890 U	1.500 J	1.000 J	0.910 UJ	1.200 J	0.820 U
Calcium	63.6	60.8	83	162	1060.000 J*	636.000 J *	814.000 J *	749.000 J *	149
Chromium	3.4	1.7	3.1	6.2	18.4 *	11.9 *	13.8 *	16.6 *	3.4
Cobalt	1.270 U	1.490 U	1.430 U	1.8	2.1	5.9	5.7	5.1	2
Copper	1.060 U	1.490 U	1.430 U	1.560 U	7.3 *	2.6	3.8	3	1.440 U
Iron	4180	1680	2460	9980	21700.000 J *	14600.000 J *	19900.000 J *	21700.000 J *	3290
Lead	2.1	5.8	1.600 J	4.5	24.4 *	14.8	20 *	23.3 *	1.8
Magnesium	140	77.9	80.5	177	352	359	390 *	486 *	150
Manganese	11.9	13.7	5.4	37.9	78.500 J	85.100 J	119.000 J	90.500 J	15.500 J
Mercury	0.060 R	0.06	0.06	0.060 U	0.060 U	0.060 U	0.060 U	0.060 U	0.25 *
Nickel	3.810 U	3.830 U	3.690 U	4.000 U	8.6 *	8.2 *	6.4	7	3.690 U
Potassium	278	191.000 U	184.000 U	199.000 U	227	380	380	525	188
Selenium	0.430 UJ	0.430 UJ	0.420 UJ	0.430 U	0.450 UJ	0.440 UJ	0.470 UJ	0.480 UJ	0.420 UJ
Silver	1.270 U	1.700 U	1.640 U	1.780 U	1.360 R	1.350 R	1.370 R	1.440 R	1.640 U
Sodium	20.6	24.900 U	24.000 U	26.000 U	11.500 UJ	11.500 UJ	11.600 UJ	12.300 UJ	32.1
Thallium	0.430 U	0.430 U	0.420 U	0.430 U	0.450 UJ	0.440 U	0.470 U	0.480 U	0.420 UJ
Vanadium	5.8	2.2	2.6	7.7	19.2	18.2	13.5	18.6	4.8
Zinc	3.000 J	1.4	1.230 U	5.500 J	67.4 *	36.5 *	22.6 *	29.1 *	7.9

Round One Inorganic Concentrations in Surface and Subsurface Soil (mg/kg)
Table 1-1 (Continued)

SITE ID	3SB15-002	3SB18-001	3SB18-002
ANALYTE			
Aluminum	2070	1860.000 J	3480.000 J
Antimony	9.360 UJ	7.300 UJ	9.020 UJ
Arsenic	6	0.79	4.7
Barium	25.2	12.7	30.1
Beryllium	0.44	0.200 U	0.35
Cadmium	1.040 U	0.810 U	1.000 U
Calcium	228000	139000 *	286
Chromium	7.7	7.4	3.6
Cobalt	3.3	3.2	2.8
Copper	3	3.4	2.4
Iron	13500	9410.000 J	3460.000 J
Lead	3.8	2.320 J	2.320 J
Magnesium	2850	5830 *	200
Manganese	314.000 J	171.000 J *	144.000 J
Mercury	0.060 U	0.060 U	0.070 U
Nickel	5	4.600 U	4.510 U
Potassium	697	542 *	224.000 U
Selenium	5.200 UJ	0.320 U	5.180 U
Silver	2.080 U	1.620 U	2.000 U
Sodium	1290	814 *	29.300 U
Thallium	0.520 UJ	0.32	0.520 U
Vanadium	17.1	12.500 J	4.500 J
Zinc	18	16.5	8.400 J

J = Estimated concentration.
UJ = Estimated nondetection.
U = Detected below reported detection limit.
R = Data rejected due to QC difficulties.
* = Compound present at a concentration greater than twice the maximum background concentration detected in the samples collected as part of the Round I RI field activities.

Round One Inorganic Concentrations in Groundwater (µg/L)
Table 1-2

SITE ID	Federal	Federal	VGS	1GW04-001	1GW05-001	1GW12-001	1GW13-001
ANALYTE	MCL	SMCL					
Aluminum		200		6,430 J (c) *	10,500 J (c) *	389 J (c)	377 J (c)
Aluminum (dissolved)				35.00 U	834 J	61.40 J	67.20 J
Antimony	6			44.00 U	44.00 U	44.00 U	44.00 U
Antimony (dissolved)				44.00 U	44.00 U	44.00 U	44.00 U
Arsenic	50		50	5.50 J	6.70 J	2.00 UJ	2.00 UJ
Arsenic (dissolved)				4.30 J	2.00 UJ	2.00 UJ	2.00 UJ
Barium	2,000		1,000	78.40	52.70	67.40	61.60
Barium (dissolved)				29.30	30.00	68.80	63.20
Beryllium	4			1.00 U	2.00	1.00 U	1.00 U
Beryllium (dissolved)				1.00 U	1.40	1.00 U	1.00 U
Cadmium	5		0.04	4.00 U	4.00 U	5.90 (d)	4.00 U
Cadmium (dissolved)				4.00 U	4.00 U	4.00 U	4.00 U
Calcium				80,600	41,400	28,300	9,540
Calcium (dissolved)				70,900	42,300	29,100	10,100
Chromium	100		50	16.40	20.00	8.00 U	8.00 U
Chromium (dissolved)				8.00 U	8.00 U	8.00 U	8.00 U
Cobalt				6.00 U	34.00 *	6.00 U	6.00 U
Cobalt (dissolved)				6.00 U	27.90	7.50	6.00 U
Copper	1,300**	1,000	1,000	5.40	7.80	5.00 U	5.00 U
Copper (dissolved)				5.00 U	5.00 U	5.00 U	5.00 U
Iron		300	300	17,900 J (e)	29,100 J (e)	1,390 J (e)	652 J (e)
Iron (dissolved)				474 J (e)	1,770 J (e)	504 J (e)	19.00 U
Lead	15**		50	8.50 J	5.10 J	3.80 J	4.30 J
Lead (dissolved)				2.00 UJ	20.00 UJ	2.00 UJ	2.00 UJ
Magnesium				3,480 J	29,400 J *	4,970 J *	3,680 J
Magnesium (dissolved)				3,850 J*	28,600 J *	5,220 J *	4,240 J *
Manganese		50	50	114 (e)	355 (e) *	127 (e)	84.70 (e)
Manganese (dissolved)				68.20 (e) *	254 (e) *	141 (e) *	69.20 (e) *
Mercury	2		0.05	0.10 U	0.10 U	0.10 U	0.10 U
Mercury (dissolved)				0.10 U	0.10 U	0.10 U	0.10 U
Nickel	100			18.00 U	26.60	18.00 U	18.00 U
Nickel (dissolved)				18.00 U	18.00 U	18.00 U	18.00 U
Potassium				1,910	3,720	3,590	1,470
Potassium (dissolved)				1,720	2,840	3,450 *	1,800
Selenium	50		10	2.00 UJ	2.00 U	2.00 U	2.00 U
Selenium (dissolved)				2.00 UJ	2.00 UJ	2.00 UJ	2.00 UJ
Silver		100		6.00 U	6.00 U	6.00 U	6.00 U
Silver (dissolved)				6.00 U	6.00 U	6.00 U	6.00 U
Sodium			100,000	7,750 J	19,600 J *	2,480 J	2,550 J
Sodium (dissolved)				7,530 J	20,000 J *	2,500 J	2,730 J
Thallium	2			2.00 UJ	2.00 UJ	2.00 UJ	2.00 U
Thallium (dissolved)				2.00 U	2.00 U	2.00 U	2.00 U
Vanadium				22.20	22.10	6.00 U	6.00 U
Vanadium (dissolved)				8.90	8.30	6.00 U	6.00 U
Zinc		5,000	50	42.80	72.90 (a)	1,650 (a) *	22.60
Zinc (dissolved)				8.10 U	70.60 (a)	1,080 (a)	9.30 U
Nitrates	10,000		5,000	100 UJ	100 UJ	2400 J	3400 J

Round One Inorganic Concentrations in Groundwater (µg/L)
Table 1-2 (Continued)

SITE ID	Federal	Federal	VGS	1GW14-001	1GW17-001	1GW17-101	3GW06-001
ANALYTE	MCL	SMCL					
Aluminum		200		401 J (c)	1,400 J (c)	1,140 J (c)	10,600 (c) *
Aluminum (dissolved)				111 J	345 J (c)	296 J (c)	35.00 U
Antimony	6			44.00 U	44.00 U	44.00 U	44.00 U
Antimony (dissolved)				44.00 U	44.00 U	44.00 U	44.00 U
Arsenic	50		50	2.00 U	2.00 U	2.00 U	20.40 J
Arsenic (dissolved)				2.00 UJ	2.00 UJ	2.00 UJ	2.00 UJ
Barium	2,000		1,000	38.80	25.20	28.10	88.50
Barium (dissolved)				35.30	21.20	21.00	25.30
Beryllium	4			1.00 U	1.00 U	1.00 U	1.60
Beryllium (dissolved)				1.00 U	1.00 U	1.00 U	1.00 U
Cadmium	5		0.04	4.00 U	4.00 U	4.00 U	4.00 U
Cadmium (dissolved)				4.00 U	4.00 U	4.00 U	4.00 U
Calcium				5,490	9,470	9,000	140,000
Calcium (dissolved)				5,010	9,190	9,490	90,500
Chromium	100		50	8.00 U	8.00 U	8.00 U	54.30 (a) *
Chromium (dissolved)				8.00 U	8.00 U	8.00 U	8.00 U
Cobalt				17.90 *	6.00 U	6.00 U	10.10
Cobalt (dissolved)				16.40	6.00 U	6.00 U	6.00 U
Copper	1,300**	1,000	1000	5.00 U	5.00 U	5.00 U	14.60
Copper (dissolved)				5.00 U	5.00 U	5.00 U	5.00 U
Iron		300	300	906 J (e)	2,460 J (e)	1,920 J (e)	44,600 J (e)
Iron (dissolved)				443 J (e)	43.50 J	39.40 J	139 J
Lead	15**		50	5.10 J	2.30 J	2.20 J	15.20 (b)
Lead (dissolved)				2.00 UJ	2.00 UJ	2.00 UJ	16.80 (b)
Magnesium				1,090 J	4,410 J	4,320 J	7,130 *
Magnesium (dissolved)				1,120 J	4,370 J *	4,430 J *	2,220
Manganese		50	50	30.70	164 (e)	163 (e)	207 (e)
Manganese (dissolved)				23.70	140 (e) *	138 (e) *	22.20
Mercury	2		0.05	0.10 U	0.10 U	0.10 U	0.10 U
Mercury (dissolved)				0.10 U	0.10 U	0.10 U	0.10 U
Nickel	100			18.00 U	18.00 U	18.00 U	21.30
Nickel (dissolved)				18.00 U	18.00 U	18.00 U	18.00 U
Potassium				970U	2,930	2,380	4,960
Potassium (dissolved)				970U	3,140	3,120	1,160
Selenium	50		10	2.00 U	2.00 UJ	2.00 U	2.00 UJ
Selenium (dissolved)				2.00 UJ	2.00 UJ	2.00 UJ	2.00 UJ
Silver		100		6.00 U	6.00 U	6.00 U	6.00 U
Silver (dissolved)				6.00 U	6.00 U	6.00 U	6.00 U
Sodium			100,000	2,610 J	1,880 J	1,810 J	6,680
Sodium (dissolved)				2,480 J	1,650 J	1,630 J	6,540
Thallium	2			2.00 U	2.00 U	2.00 U	2.00 UJ
Thallium (dissolved)				2.00 U	2.00 U	2.00 U	2.00 UJ
Vanadium				6.00 U	6.00 U	6.00 U	49.00 *
Vanadium (dissolved)				6.00 U	6.00 U	6.00 U	11.60
Zinc		5,000	50	28.20	20.10 U	16.60 U	82.10 J (a)
Zinc (dissolved)				39.40	9.20 U	10.60 U	59.80 J (a)
Nitrates	10,000		5,000	150 J	6400 J (a)	8200 J (a)	100 U

Round One Inorganic Concentrations in Groundwater (µg/L)
Table 1-2 (Continued)

SITE ID	Federal	Federal	VGS	3GW07-001	3GW08-001	3GW15-001	3GW18-001
ANALYTE	MCL	SMCL					
Aluminum		200		6,970 J (c) *	34,900 J (c) *	202,000 J (c)*	6,450 J (c) *
Aluminum (dissolved)				35.00 U	35.00 U	43.70 J	1,620 J (c)
Antimony	6			44.00 U	44.00 U	44.00 U	44.00 U
Antimony (dissolved)				44.00 U	44.00 U	44.00 U	44.00 U
Arsenic	50		50	13.60 J	17.80 J	4.10 J	2.00 UJ
Arsenic (dissolved)				2.00 UJ	2.00 UJ	2.00 UJ	2.00 UJ
Barium	2,000		1,000	69.00	163*	1,220 (a) *	96.40
Barium (dissolved)				34.80	28.80	35.80	74.70 *
Beryllium	4			1.10	4.70 (b) *	23.30 (b) *	1.00 U
Beryllium (dissolved)				1.00 U	1.00 U	1.00 U	1.00 U
Cadmium	5		0.04	4.00 U	8.40 (d)	29.70 (d)	4.00 U
Cadmium (dissolved)				4.00 U	4.00 U	4.00 U	4.00 U
Calcium				171,000	370,000 *	2,320,000 *	310,000 *
Calcium (dissolved)				132,000	138,000	134,000	325,000 *
Chromium	100		50	38.20	188 (d) *	1,100 (d) *	17.00
Chromium (dissolved)				8.00 U	8.00 U	8.00 U	8.00 U
Cobalt				6.00 U	29.40 *	191.00 *	8.00
Cobalt (dissolved)				6.00 U	6.00 U	6.00 U	6.00 U
Copper	1,300 **	1,000	1000	9.90	38.30 *	287 *	10.90
Copper (dissolved)				5.00 U	5.00 U	5.00 U	5.20
Iron		300	300	22,900 J (e)	107,000 J (e) *	667,000 J (e) *	18,600 J (e)
Iron (dissolved)				19.00 UJ	25.40 J	82.80 J	19.00 UJ
Lead	15 **		50	10.30 U	118 (d) *	146 J (d) *	6.90 U
Lead (dissolved)				2.00 U	2.00 U	2.50 U	2.00 U
Magnesium				5,480 *	15,900 *	75,000 *	1,820
Magnesium (dissolved)				2,990	3,410	3,230	266
Manganese		50	50	110 (e)	492 (e) *	4,810 (e) *	75.40 (e)
Manganese (dissolved)				2.00 U	6.30	128 (e) *	2.00 U
Mercury	2		0.05	0.10 U	0.10 U	0.54 (a) *	0.10 U
Mercury (dissolved)				0.10 U	0.10 U	0.10 U	0.10 U
Nickel	100			18.00 U	84.10	594 (b)	18.00 U
Nickel (dissolved)				18.00 U	18.00 U	18.00 U	18.00 U
Potassium				3,950	12,100 *	46,400 *	18,100 *
Potassium (dissolved)				970 U	970 U	2,200	18,600 *
Selenium	50		10	2.00 UJ	20.00 UJ	20.00 UJ	2.00 UJ
Selenium (dissolved)				2.00 UJ	2.00 UJ	2.00 UJ	2.00 UJ
Silver		100		6.00 U	7.30	44.20	6.00 U
Silver (dissolved)				6.00 U	6.00 U	6.00 U	6.00 U
Sodium			100,000	10,900	11,200	23,300 *	25,500 *
Sodium (dissolved)				10,700 *	11,400 *	14,400 *	28,400 *
Thallium	2			20.00 U	2.00 U	2.00 UJ	2.00 U
Thallium (dissolved)				2.00 U	2.00 U	20.00 U	2.00 U
Vanadium				56.50 *	204 *	498 *	42.30 *
Vanadium (dissolved)				15.20	16.80	13.90	26.60
Zinc		5,000	50	49.20 J	218 J (a) *	2,840 J (a) *	35.90 J
Zinc (dissolved)				134 J (a)	35.40 J	89.70 J (a)	190 J (a)
Nitrates	10,000		5,000	170	100 U	120	110

Shaded cell indicates concentration exceeds one or more criteria

(a) Exceeds VGS
(b) Exceeds federal MCL
(c) Exceeds federal SMCL
(d) Exceeds federal MCL and VGS
(e) Exceeds SMCL and VGS

J =Estimated concentration
UJ = Estimated nondetection
U = Detected below reported detection limit
R = Data rejected due to QC difficulties
* Compound present at a concentration greater than twice the maximum background concentration detected in the samples

Round One Inorganic Concentrations in Surface Water (µg/L)
Table 1-3

SITE ID	VWQS	CWA	1SW05-001	1SW06-001	1SW06-101	1SW07-001	1SW08-001
ANALYTE	Criteria	Criteria					
Aluminum			7,650	4,120	4,940	599	462
Aluminum (dissolved)			49.40 U	37.00 U	37.00 U	35.00 U	35.00 U
Antimony			44.00 U	44.00 U	44.00 U	44.00 U	44.00 U
Antimony (dissolved)			44.00 U	44.00 U	45.30	44.00 U	44.00 U
Arsenic		190/36	20.00 UJ	20.00 UJ	20.00 UJ	20.00 UJ	20.00 U
Arsenic (dissolved)			20.00 U	20.00 UJ	20.00 U	20.00 UJ	20.00 UJ
Barium			30.70	27.90	32.10	26.00	25.80
Barium (dissolved)			32.60	29.70	31.80	44.90	27.00
Beryllium			1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
Beryllium (dissolved)			1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
Cadmium	--/9.3	1.1/--	4.00 U	4.00 U	4.00 U	4.00 U	4.00 U
Cadmium (dissolved)			4.00 U	4.00 U	4.00 U	4.00 U	4.00 U
Calcium			119,000	158,000	165,000	189,000	200,000
Calcium (dissolved)			120,000	150,000	147,000	188,000	201,000
Chromium	11/50		18.50	8.00	8.00 U	8.00 U	8.00 U
Chromium (dissolved)			8.00 U	8.00 U	8.00 U	8.00 U	8.00 U
Cobalt			6.00 U	6.00 U	6.00 U	6.00 U	6.00 UJ
Cobalt (dissolved)			6.00 U	6.00 U	6.00 U	6.00 U	6.00 UJ
Copper	--/2.9	12/2.9	29.70 (c)	9.20 (c)	31.00 (c)	5.00 U	5.00 U
Copper (dissolved)			5.00 U	5.00 U	5.00 U	5.00 U	6.90 (c)
Iron			12,800	6,510	8,320	1,210	855
Iron (dissolved)			67.60 U	19.00 U	19.00 U	19.00 U	19.00 U
Lead		3.2/8.5	20.00 UJ	20.00 UJ	20.00 UJ	278 J (a) *	20.00 U
Lead (dissolved)			2.00 U	2.00 U	2.00 U	269 J (a)	21.00 J (a)
Magnesium			357,000 *	498,000 *	524,000 *	591,000 *	699,000 *
Magnesium (dissolved)			359,000 *	468,000 *	460,000 *	590,000 *	706,000 *
Manganese			239	170	201	92.10	83.90
Manganese (dissolved)			83.70	87.80	86.30	53.70	51.80
Mercury	.012/.025	.012/.025	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U
Mercury (dissolved)			0.10 U	0.10 U	0.10 U	0.10 U	0.11 (c)
Nickel	--/8.3	160/8.3	23.70 (c)	20.30 (c)	18.70 (c)	18.00 U	18.00 U
Nickel (dissolved)			18.00 U	18.00 U	18.00 U	18.00 U	18.00 U
Potassium			123,000 *	163,000 *	173,000 *	189,000 *	222,000 *
Potassium (dissolved)			126,000 *	159,000 *	159,000 *	193,000 *	224,000 *
Selenium	5/71	5/71	20.00 UJ	20.00 UJ	20.00 UJ	20.00 U	20.00 UJ
Selenium (dissolved)			2.00 UJ	2.00 UJ	2.00 UJ	20.00 UJ	20.00 UJ
Silver			6.00 U	6.00 U	6.00 U	6.00 U	6.00 UJ
Silver (dissolved)			6.00 U	6.00 U	6.00 U	6.00 U	6.00 UJ
Sodium			3,090,000 *	4,280,000 *	4,450,000 *	5,150,000 *	5,490,000 *
Sodium (dissolved)			3,140,000 *	4,080,000 *	4,050,000 *	4,990,000 *	5,550,000 *
Thallium			20.00 UJ	20.00 UJ	20.00 UJ	20.00 UJ	20.00 UJ
Thallium (dissolved)			20.00 UJ	20.00 UJ	20.00 UJ	20.00 UJ	20.00 UJ
Vanadium			17.80	14.70	16.10	13.60	6.00 U
Vanadium (dissolved)			6.00 U	6.00 U	9.50	12.20	6.00 U
Zinc	--/86	110/86	58.60	41.20	44.90	9.30	15.20
Zinc (dissolved)			12.90 U	9.10 U	9.60 U	8.60	15.70

Round One Inorganic Concentrations in Surface Water (µg/L)
Table 1-3 (continued)

SITE ID	VWQS	CWA	1SW09-001	1SW10-001	3SW01-001	3SW02-001
ANALYTE	Criteria	Criteria				
Aluminum			669	69.10	2,220	2,230
Aluminum (dissolved)			75.60 U	35.00 U	50.40 U	103 U
Antimony			44.00 U	44.00 U	60.00 U	44.00 U
Antimony (dissolved)			44.00 U	44.00 U	60.00 U	44.00 U
Arsenic		190/36	2.00 U	5.40 J	2.00 UJ	2.10 J
Arsenic (dissolved)			2.70	3.60 J	2.00 UJ	2.00 UJ
Barium			30.40	42.80	23.60	20.40
Barium (dissolved)			31.80	45.90	17.10	29.70
Beryllium			1.00 U	1.00 U	1.00 U	1.00 U
Beryllium (dissolved)			1.00 U	1.00 U	1.00 U	1.00 U
Cadmium	--/9.3	1.1/--	4.00 U	4.00 U	7.00 U	4.00 U
Cadmium (dissolved)			4.00 U	4.00 U	7.00 U	4.00 U
Calcium			62,500	7,190	70,800	48,600
Calcium (dissolved)			60,900	5,350	73,000	45,400
Chromium	11/50		8.00 U	8.00 U	9.00 U	13.70
Chromium (dissolved)			8.00 U	8.00 U	9.00 U	8.00 U
Cobalt			6.00 U	6.00 U	9.00 U	6.00 U
Cobalt (dissolved)			6.00 U	6.00 U	9.00 U	6.00 U
Copper	--/2.9	12/2.9	10.00 (c)	5.00 U	12.00 (c)	5.00 U
Copper (dissolved)			5.00 U	14.20 (d)	8.00 U	5.00 U
Iron			1,720	6,660	4,110	4,060
Iron (dissolved)			112 U	1,350 *	217	452
Lead		3.2/8.5	2.00 UJ	2.00 J	2.00 U	2.80 J
Lead (dissolved)			2.00 U	2.00 UJ	2.00 U	2.00 U
Magnesium			17,900	670	131,000 J	88,200
Magnesium (dissolved)			16,700	708	135,000 J	83,800
Manganese			57.30	840	128	168
Manganese (dissolved)			42.20	57.40	93.20	134
Mercury	.012/.025	.012/.025	0.10 U	0.10 U	0.10 U	0.10 R
Mercury (dissolved)			0.10 U	0.10 U	0.13 U	0.10 U
Nickel	--/8.3	160/8.3	18.00 U	18.00 U	20.00 U	18.00 U
Nickel (dissolved)			18.00 U	18.00 U	20.00 U	18.00 U
Potassium			6,770	1,680	50,600	30,900
Potassium (dissolved)			5,460	970 U	52,000	28,700
Selenium	5/71	5/71	2.00 UJ	2.00 U	2.00 UJ	2.00 UJ
Selenium (dissolved)			2.00 UJ	2.00 U	2.00 UJ	2.00 UJ
Silver			6.00 U	6.00 U	10.00 R	6.00 U
Silver (dissolved)			6.00 U	6.00 U	10.00 R	6.00 U
Sodium			125,000	1,010 J	1,630,000	673,000
Sodium (dissolved)			119,000	1,260 J	1,270,000	685,000
Thallium			2.00 UJ	2.00 UJ	20.00 UJ	2.00 UJ
Thallium (dissolved)			2.00 UJ	2.00 UJ	2.00 UJ	2.00 UJ
Vanadium			6.00 U	6.00 U	15.40	13.30
Vanadium (dissolved)			6.00 U	6.00 U	14.00	6.00 U
Zinc	--/86	110/86	17.90	21.60	23.30	22.30
Zinc (dissolved)			9.70 U	28.20	10.70	13.40 U

Shaded cell indicates concentration exceeds one or more criteria
(a) Exceeds CWA salt water chronic criteria
(b) Exceeds VWQS salt water chronic criteria
(c) Exceeds VWQS and CWA salt water chronic criteria
(d) Exceeds CWQ fresh water chronic criteria

J = Estimated Concentration
UJ = Estimated nondetection
U = Detected below reported detection limit
R = Data rejected due to QC difficulties
*Compound present at a concentration greater than twice the maximum background concentration detected in the samples collected as part of the Round 1 RI field activities

Round One Inorganic Concentrations in Sediment (mg/kg)
Table 1-4

SITE ID	NOAA	NOAA	NOAA	1SD05-001	1SD05-002	1SD06-001	1SD06-101	1SD06-002	1SD06-102	1SD07-001
ANALYTE	ER-L	ER-M	AET							
Aluminum				8410	10100	9590	5860	7610	8580	5640
Antimony	2	25	25	23.200 UJ	19.300 UJ	24.500 UJ	20.700 UJ	21.200 UJ	21.700 UJ	11.2 (a)
Arsenic	33	85	50	8.7	9.6	9.4	5	9.1	9.4	3.300 J
Barium				19.3	22	20.6	12.9	18	19.3	10.7
Beryllium				0.84 *	0.84 *	0.89 *	0.52	0.92 *	0.74 *	0.4
Cadmium	5	9	5	2.110 U	1.760 U	2.230 U	1.880 U	1.930 U	1.980 U	1.000 U
Calcium				1930	1860	2230	1560	1620	1680	904
Chromium	80	145		22.5	89.6 * (a)	25.1	13.2	20.1	20.9	14.3
Cobalt				6.8	9.1	5.1	4.1	6.9	5.2	3.500 U
Copper	70	390	300	14.7	20.7	18.9	11.9	16.3	25.4	6
Iron				27500	31900	31000	19000	29000	29400	10900
Lead	35	110	300	21.500 J	22.200 J	21.600 J	16.900 J	17.400 J	21.600 J	9.1
Magnesium				5540	5780	5990	4310	4950	5300	2730
Manganese				191	260	194	124	228	222	67.8
Mercury	0.15	1.3	1	0.130 U	0.110 U	0.140 U	0.130 U	0.130 U	0.130 U	0.060 U
Nickel	30	50		16.1	162 * (b)	10.000 U	12.9	13.9	14.6	7.8
Potassium				3090	3010	2970	1760	2550	2440	1510
Selenium				9.800 UJ	8.430 UJ	11.100 UJ	9.600 UJ	10.200 UJ	9.850 UJ	0.490 U
Silver	1	2.2	1.7	3.170 UJ	2.640 UJ	3.340 UJ	2.830 UJ	2.890 UJ	2.970 UJ	1.490 U
Sodium				12200	9560	13300	12300	11000	10600	6430
Thallium				0.980 UJ	0.840 UJ	1.110 UJ	9.600 UJ	1.020 UJ	0.990 UJ	0.490 UJ
Vanadium				30.8	31.8	32.4	18.3	26.1	27.8	14
Zinc	120	270	260	98.2	108	101	68.1	69	84.3	39.7

Round One Inorganic Concentrations in Sediment (mg/kg)
Table 1-4 (continued)

SITE ID	NOAA	NOAA	NOAA	1SD07-101	1SD07-002	1SD08-001	1SD08-002	1SD09-001	1SD09-002	1SD10-001
ANALYTE	ER-L	ER-M	AET							
Aluminum				14600	13800	11100	13900	2840	1630	2010
Antimony	2	25	25	27.300 U	19.100 U	33.700 U	31.000 U	14.100 UJ	12.700 UJ	11.300 U
Arsenic	33	85	50	9.400 J	12.300 J	6.5	9.6	2.9	1.9	3.200 J
Barium				28.8	27.2	20.1	28.2	6.5	3.6	4.8
Beryllium				1.1 *	0.91 *	1.5 *	1.7 *	0.320 U	0.290 U	0.260 U
Cadmium	5	9	5	2.480 U	1.730 U	3.070 U	2.820 U	1.280 U	1.150 U	1.020 U
Calcium				4380	2020	3090	2560	1000	870	77.8
Chromium	80	145		36.7	34.3	28.4	38.6	6.4	3.9	6.3
Cobalt				10.4	9.8	5.3	13.2	2.4	1.730 U	2.000 U
Copper	70	390	300	19.3	17.9	11.4	19.8	1.600 U	1.440 U	1.280 U
Iron				29000	29800	25200	34800	8690	5630	3980
Lead	35	110	300	26	24.7	24.5	27.4	8.200 J	4.200 J	3.3
Magnesium				7200	5700	6640	6780	1840	772	333
Manganese				187	172	190.000 J	263.000 J	64.9	36.4	9.8
Mercury	0.15	1.3	1	0.160 U	12.000 U	0.210 U	0.190 U	0.080 U	0.080 U	0.060 U
Nickel	30	50		18.2	20	13.800 U	20.6	5.760 U	5.200 U	4.610 U
Potassium				3850	3240	2740	3980	1050	352	431
Selenium				1.280 UJ	0.920 UJ	1.540 UJ	1.460 UJ	6.050 UJ	0.560 UJ	0.510 U
Silver	1	2.2	1.7	3.720 U	2.600 U	4.600 UJ	4.220 UJ	1.920 UJ	1.730 UJ	1.540 U
Sodium				16300	7830	19200	11800	4110	1090	19.6
Thallium				12.800 U	0.920 UJ	15.400 UJ	1.460 UJ	0.610.UJ	0.560 UJ	0.510 U
Vanadium				34.6	38.4	29.7	44.9	9.6	4.7	6.2
Zinc	120	270	260	109	89	100.000 J	122 J (a)	35.4	17.1	6.7

Round One Inorganic Concentrations in Sediment (mg/kg)
Table 1-4 (continued)

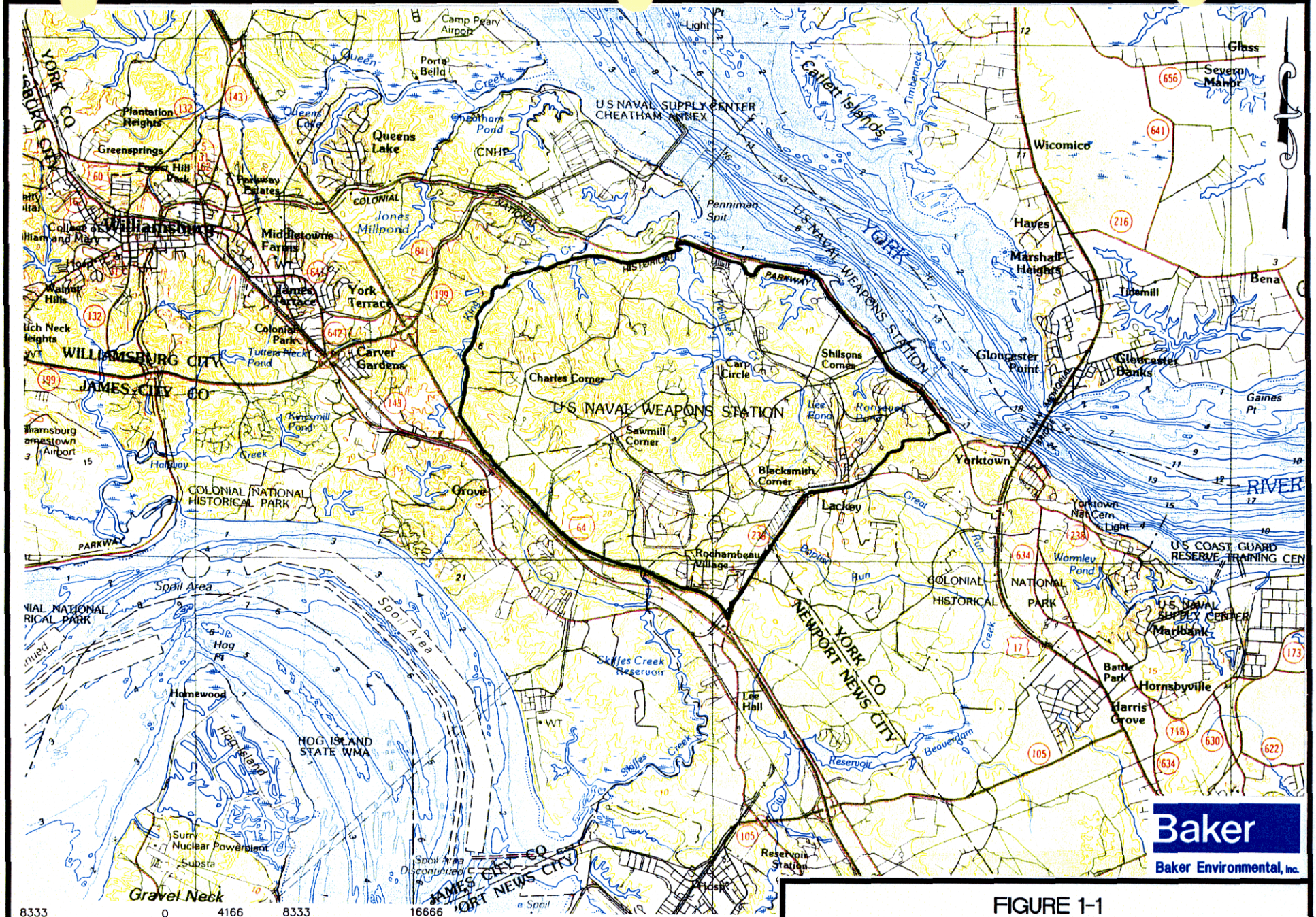
SITE ID	NOAA	NOAA	NOAA	1SD10-002	1SD11-001	1SD11-002	1SD12-001	1SD12-002
ANALYTE	ER-L	ER-M	AET					
Aluminum				2420	194.000 J	691.000 J	1790	1090
Antimony	2	25	25	10.7U	11.500 UJ	10.900 UJ	10.100 U	10.300 U
Arsenic	33	85	50	1.8J	0.750 J	0.790 J	0.690 J	0.460 UJ
Barium				4.8	2.700 J	4.600 J	6.8	4.1
Beryllium				0.24U	0.260 U	0.32	0.28	0.230 U
Cadmium	5	9	5	1.4U	1.050 UJ	0.990 UJ	0.920 U	0.930 U
Calcium				90.5	576.000 J	441.000 J	460	249
Chromium	80	145		6.6	2.090 J	2.800 J	2.3	1.870 U
Cobalt				2.00 U	1.570 U	1.480 U	2.400 U	1.700 U
Copper	70	390	300	1.3	1.800 J	2.900 J	1.150 U	1.170 U
Iron				3850	653.000 J	833.000 J	2570	1600
Lead	35	110	300	2.5	1.300 J	2.800 J	5	1.8
Magnesium				388	32.900 U	51.3	144	102
Manganese				8.6	6.200 J	4.600 J	42.9	7.3
Mercury	0.15	1.3	1	0.06U	0.070 U	0.070 U	0.060 U	0.060U
Nickel	30	50		4.38 U	4.700 U	5.5	4.140 U	4.200 U
Potassium				721	253.000 U	240.000 U	223.000 U	226.000 U
Selenium				0.50U	0.520 UJ	0.500 UJ	0.570 J	0.460 U
Silver	1	2.2	1.7	1.46U	1.540 UJ	1.560 UJ	1.380 U	1.400 U
Sodium				39.4	48.6	117	89.6	44.8
Thallium				0.50U	0.520 UJ	0.500 UJ	0.470 U	0.460 U
Vanadium				7.1	1.570 U	1.8	4.1	1.9
Zinc	120	270	260	7.1	14.500 J	12.900 J	14.1	7.2

Round One Inorganic Concentrations in Sediment (mg/kg)
Table 1-4 (continued)

SITE ID	3SD01-001	3SD01-002	3SD02-001	3SD02-002
ANALYTE				
Aluminum	4910	2980	8460	9690
Antimony	26.000 U	17.400 U	35.800 UJ	27.300 UJ
Arsenic	3.9	3.6	5.7	14.1
Barium	12.4	7.3	20.8	22
Beryllium	0.430 U	0.290 U	1.1 *	0.99 *
Cadmium	3.030 U	2.030 U	3.260 U	2.480 U
Calcium	1050.000 J	1040.000 J	2280	2690
Chromium	15.200 J	7.900 J	16.7	21.7
Cobalt	3.890 U	2.610 U	4.890 U	4.8
Copper	8.4	5.3	23.8	22.7
Iron	12700.000 J	8870.000 J	23600	36400
Lead	11.3	7.8	23.200 J	29.100 J
Magnesium	2700	1140	5490	4850
Manganese	80.000 J	48.300 J	171	210
Mercury	0.110 U	0.070 U	0.210 U	0.160 U
Nickel	11.200 U	5.790 U	17.1	13.7
Potassium	1660	799	2900	2460
Selenium	0.860 UJ	0.580 UJ	16.100 UJ	12.400 UJ
Silver	4.300 U	2.900 U	4.890 UJ	3.720 UJ
Sodium	6300	1620	11900	4190
Thallium	0.860 UJ	0.580 UJ	16.100 UJ	1.240 UJ
Vanadium	11.8	10.1	28.4	31.8
Zinc	44.1	26.6	101	88.6

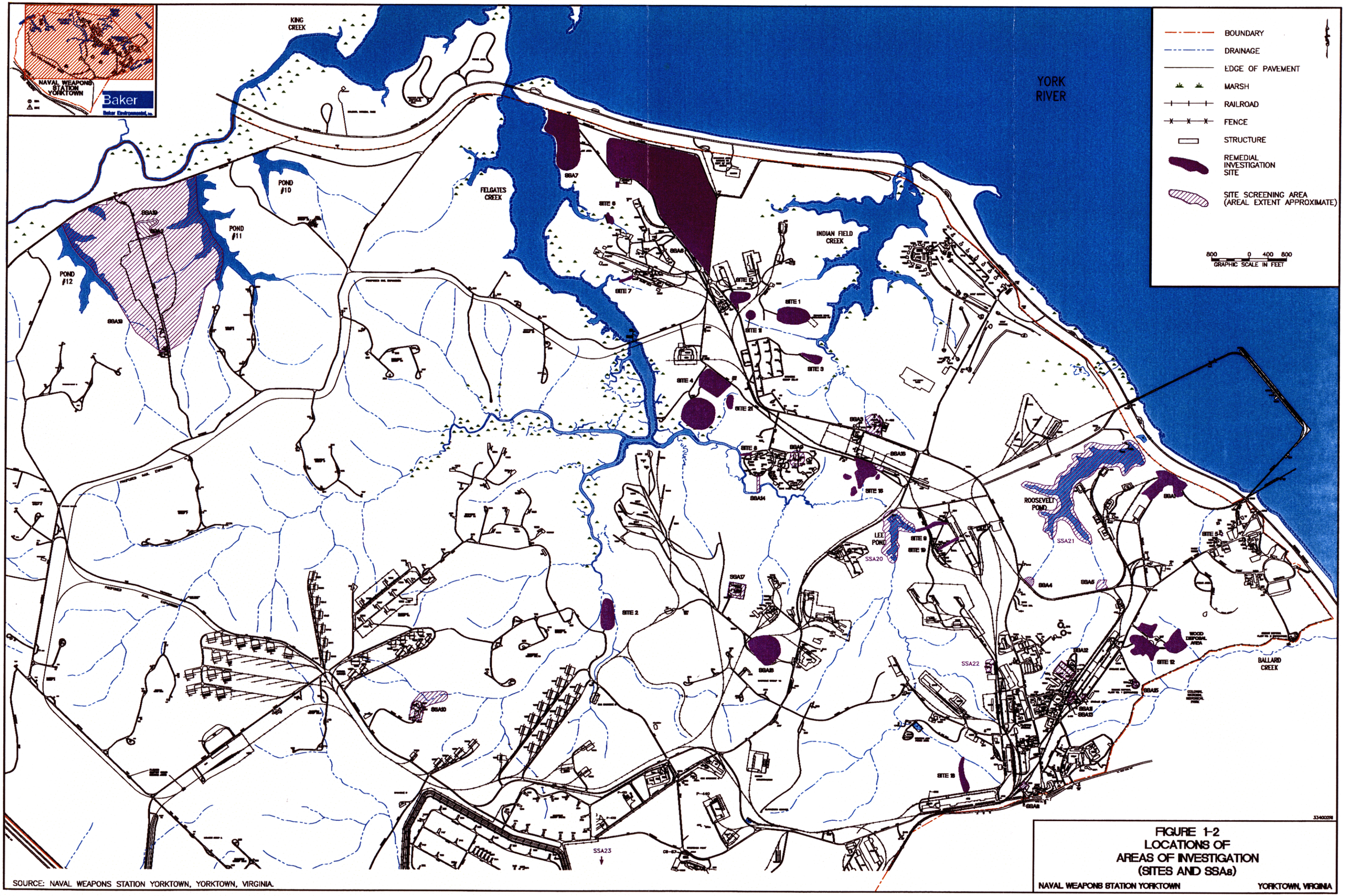
Shaded cell indicates concentration exceeds NOAA sediment screen criteria
(a)Exceeds NOAA Effects Range - Low (ER-L) level
(b)Exceeds NOAA Effects Range - Median (ER-M) level
(c) Exceeds NOAA Apparent Effects Threshold (AET)
J = Estimated concentration
UJ = Estimated nondetection
U = Detected below reported detection limit
R = Data rejected due to QC difficulties
*Compound present at a concentration greater than twice the maximum background concentration detected in the samples collected as part of the Round I RI field activities.

FIGURES



SOURCE: U.S.G.S. 1:100,000-SCALE PLANIMETRIC MAP, WILLIAMSBURG, VIRGINIA, 1984.

FIGURE 1-1
LOCATION OF NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

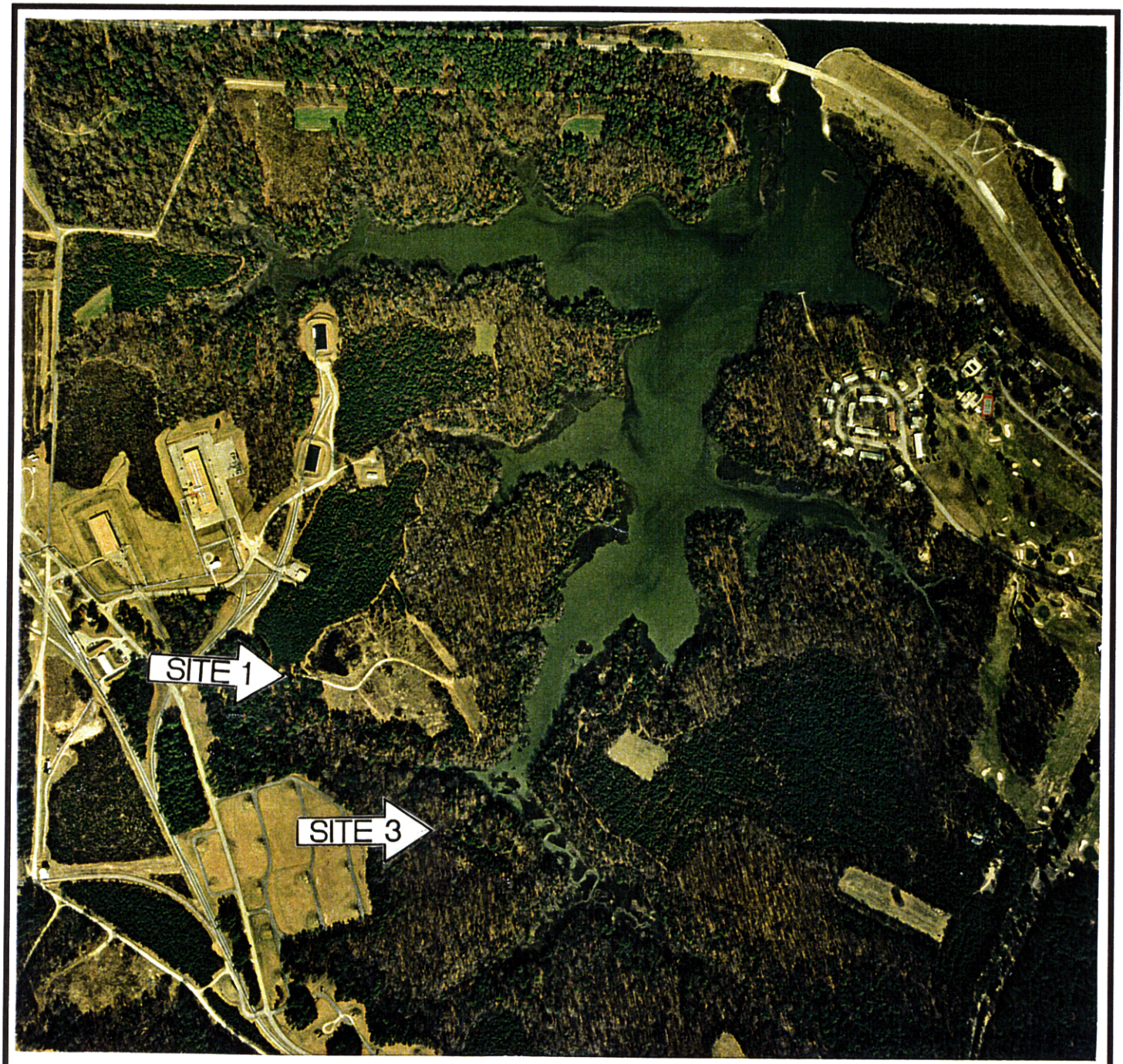


SOURCE: NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA.

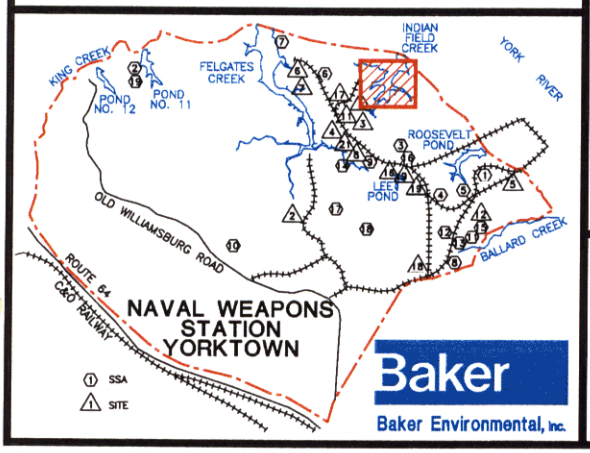
3340228

FIGURE 1-2
LOCATIONS OF
AREAS OF INVESTIGATION
(SITES AND SSAs)

NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA



N.T.S.



318501RI

FIGURE 1-3
AERIAL PHOTOGRAPH OF
SITES 1 AND 3

NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA

318502RI

SITE 1

SITE 3

WOODS

DIRT ROAD

DIRT MOUND

POND

EDGE OF WATER

DEBRIS AREA

INDIAN FIELD CREEK

EDGE OF WATER

MAG. BLDG. 266

MAG. BLDG. 267

GATE

180 0 90 180

1 inch = 180 ft.

Baker

Baker Environmental, Inc.

NOTES:

1. ELEVATIONS SHOWN WERE TAKEN FROM AN ALUMINUM RIVET LOCATED IN CONCRETE HEADWALL N. OF N. RD. TO AMMO OVERHAUL. BENCH MARK NUMBER MR-23 ELEVATION=44.11'

2. HORIZONTAL INFORMATION SHOWN WAS TAKEN FROM A DRAWING TITLED "HORIZONTAL SURVEYING CONTROL POINTS INDEX" BY TALBOT AND ASSOCIATES, LTD. CODE IDENT. NO. 80091 SHEET NUMBER I-7.

LEGEND

- EDGE OF WATER
- TREELINE
- EDGE OF PAVEMENT
- BUILDING
- WETLANDS
- DEBRIS AREA
- REMEDIAL INVESTIGATION SITE
- SUSPECTED LIMIT OF SITE

SOURCE: PHR & A, AUGUST 1995.

FIGURE 1-4
SITE MAP OF SITES 1 AND 3

NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

318503RI

1SW/SD02
1SW/SD05
1SW/SD06
1SW/SD07
(SAMPLES LOCATED DOWNSTREAM IN INDIAN FIELD CREEK)

SITE 1

SITE 3

1GW13
1GW17
1S03
1S04
1SW/SD08
1GW05
1SD12
1S05
1ST01
1S06
1ST02
1S02
1S01
1GW14
1GW12
1GW04
1SG01
1SW/SD09
1SD11
3SW/SD01
3SW/SD02
3GW08
3GW07
3ST02
3GW15
3ST01
3S01
3S03
3S02
3GW06
3GW18
11GW11
11GW11A
1SW/SD10

WOODS
POND
EDGE OF WATER
DIRT ROAD
DIRT MOUND
DEBRIS AREA
INDIAN FIELD CREEK
SEWER LINE
EDGE OF WATER
GATE
MAG. BLDG. 266
MAG. BLDG. 267

NOTES:

1. ELEVATIONS SHOWN WERE TAKEN FROM AN ALUMINUM RIVET LOCATED IN CONCRETE HEADWALL N. OF N. RD. TO AMMO OVERHAUL. BENCH MARK NUMBER MR–23 ELEVATION=44.11'
2. HORIZONTAL INFORMATION SHOWN WAS TAKEN FROM A DRAWING TITLED "HORIZONTAL SURVEYING CONTROL POINTS INDEX" BY TALBOT AND ASSOCIATES, LTD. CODE IDENT. NO. 80091 SHEET NUMBER I–7.
3. SUBSURFACE SOILS ARE LOCATED WITH THE GROUNDWATER MONITORING WELL LOCATIONS.

LEGEND

- EDGE OF WATER
- TREELINE
- EDGE OF PAVEMENT
- BUILDING
- WETLANDS
- DEBRIS AREA

SOURCE: PHR & A, AUGUST 1995.

- REMEDIAL INVESTIGATION SITE
- SUSPECTED LIMIT OF SITE
- 1GW11 – MONITORING WELL/SUBSURFACE SOIL LOCATION
- 3SW/SD01 – ROUND ONE SURFACE WATER/ SEDIMENT LOCATION
- 1SG01 – STAFF GAUGE LOCATION
- 3S03 – ROUND ONE SURFACE SOIL SAMPLE LOCATION
- 3ST01 – ROUND ONE SHELBY TUBE SAMPLE LOCATION

180 0 90 180
1 inch = 180 ft.

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FIGURE 1–5
LOCATION OF ROUND ONE RI SAMPLE STATIONS
SITES 1 AND 3

NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

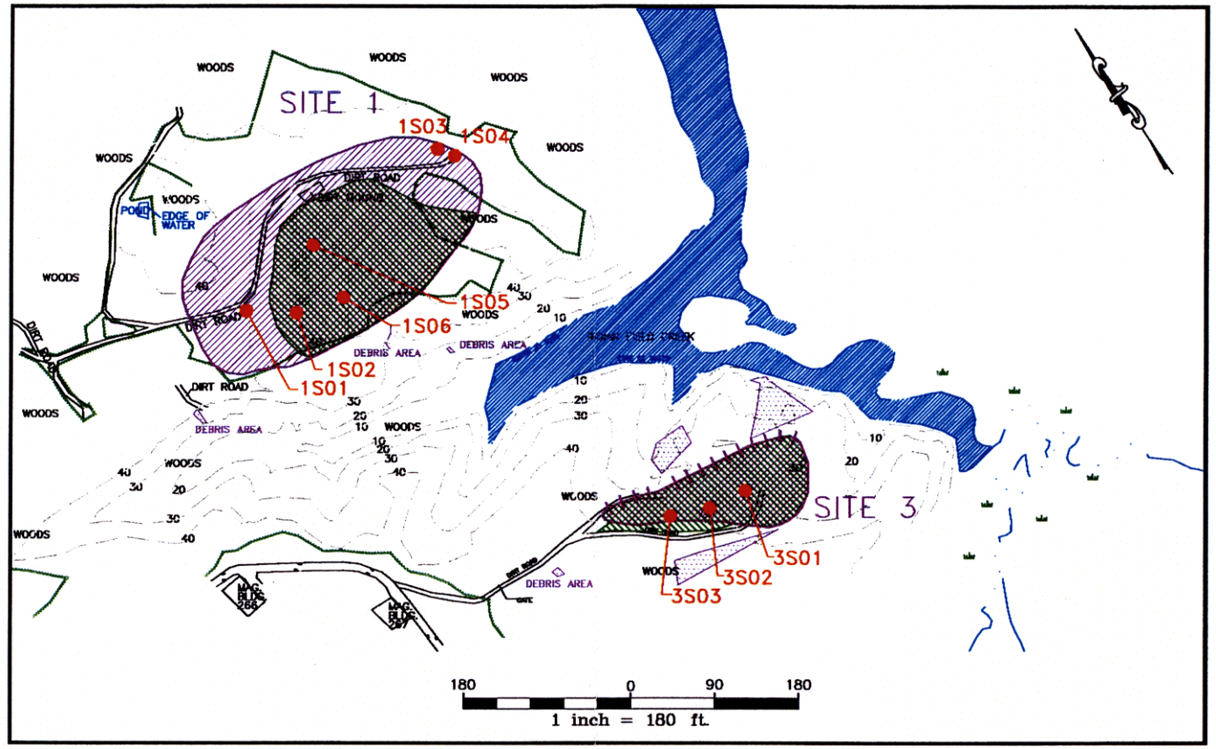
318504RI

SITE 1

1S01-001	
45 J	Di-n-butylphthalate
39 J	Bis (2-ethylhexyl) phthalate
1S02-001	
1 J	Toluene
36 J	Phenanthrene
32 J	Di-n-butylphthalate
35 J	Pyrene
680	Butylbenzyl phthalate
12000	Bis (2-ethylhexyl) phthalate
1S03-001	
41 J	Chrysene
1S04-001	
34 J	Di-n-butylphthalate
48 J	Pyrene
24 J	Benzo(a)anthracene
38 J	Chrysene
34 J	Benzo(b)fluoranthene
31 J	Benzo(k)fluoranthene
1S05-001	
41 J	Di-n-butylphthalate
1S06-001	
48 J	Di-n-butylphthalate
23 J	Fluoranthene
23 J	Pyrene
240 J	Bis(2-ethylhexyl)phthalate
20 J	Benzo(b)fluoranthene

SITE 3

3S01-001	
160 J	Phenanthrene
43 J	Anthracene
57 J	Carbazole
34 J	Di-n-butylphthalate
180 J	Fluoranthene
150 J	Pyrene
87 J	Benzo(a)anthracene
93 J	Chyrsene
69 J	Bis (2-ethylhexyl) phthalate
72 J	Benzo(b)fluoranthene
75 J	Benzo(k)fluoranthene
79 J	Benzo(a)pyrene
57 J	Indeno(1,2,3-cd)pyrene
54 J	Benzo(g,h,i)pyrene
3S02-001	
32 J	Di-n-butylphthalate
48 J	Bis (2-ethylhexyl) phthalate
3S03-001	
5 J	Toluene
30 J	Di-n-butylphthalate
28 J	Bis (2-ethylhexyl) phthalate
3S03-101	
2 J	Toluene
31 J	Di-n-butylphthalate
36 J	Bis (2-ethylhexyl) phthalate



NOTES:

1. ELEVATIONS SHOWN WERE TAKEN FROM AN ALUMINUM RIVET LOCATED IN CONCRETE HEADWALL N. OF N. RD. TO AMMO OVERHAUL. BENCH MARK NUMBER MR–23 ELEVATION=44.11'
2. HORIZONTAL INFORMATION SHOWN WAS TAKEN FROM A DRAWING TITLED "HORIZONTAL SURVEYING CONTROL POINTS INDEX" BY TALBOT AND ASSOCIATES, LTD. CODE IDENT. NO. 80091 SHEET NUMBER I–7.
3. ANALYTICAL RESULTS REPORTED IN UNITS OF MICROGRAMS PER KILOGRAM (ug/kg).

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LEGEND

- EDGE OF WATER
- TREELINE
- EDGE OF PAVEMENT
- BUILDING
- WETLANDS
- DEBRIS AREA
- REMEDIAL INVESTIGATION SITE
- SUSPECTED LIMIT OF SITE
- 3S03 – ROUND ONE SURFACE SOIL SAMPLE LOCATION

SOURCE: PHR & A, AUGUST 1995.

FIGURE 1–6
ROUND ONE RI
SELECTED ANALYTICAL RESULTS FOR SURFACE SOIL SAMPLES COLLECTED FROM SITES 1 AND 3
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

318505RI

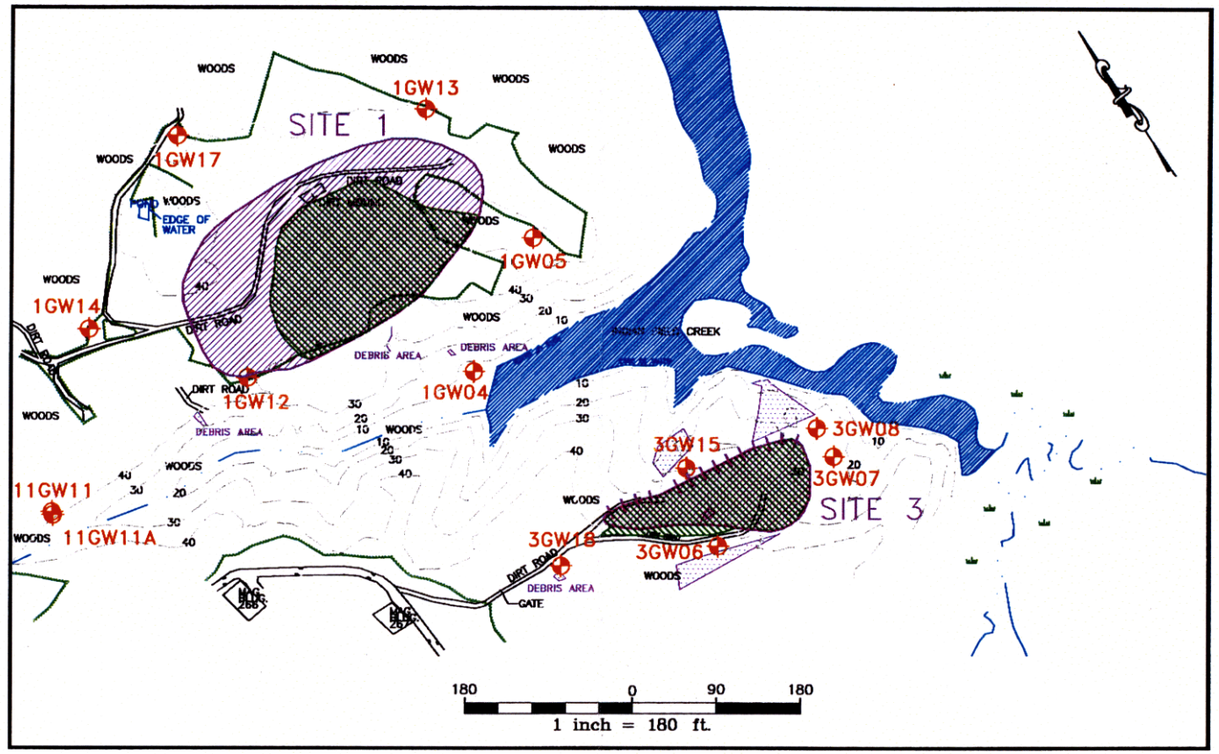
SITE 1

1GW12-001

1000 J	1,2-Dichloroethene
18000	Trichloroethene
28	1,1,2,-Trichlorethane
7 J	Tetrachloroethene
1 J	Toluene
1 J	Diethylphthalate

SITE 3

3GW06-001	
3 J	Trichloroethene
3GW07-001	
9 J	Trichloroethene
3GW08-001	
16	Trichloroethene
3GW15-001	
61	1,2-Dichloroethene
29	Chloroform
86	Trichloroethene
3GW18-001	
2 J	Phenanthrene



NOTES:

1. ELEVATIONS SHOWN WERE TAKEN FROM AN ALUMINUM RIVET LOCATED IN CONCRETE HEADWALL N. OF N. RD. TO AMMO OVERHAUL. BENCH MARK NUMBER MR-23 ELEVATION=44.11'
2. HORIZONTAL INFORMATION SHOWN WAS TAKEN FROM A DRAWING TITLED "HORIZONTAL SURVEYING CONTROL POINTS INDEX" BY TALBOT AND ASSOCIATES, LTD. CODE IDENT. NO. 80091 SHEET NUMBER 1-7.
3. ANALYTICAL RESULTS REPORTED IN UNITS OF MICROGRAMS PER LITER (ug/L).

LEGEND

- EDGE OF WATER
- TREELINE
- EDGE OF PAVEMENT
- BUILDING
- WETLANDS
- DEBRIS AREA
- REMEDIAL INVESTIGATION SITE
- SUSPECTED LIMIT OF SITE
- MONITORING WELL LOCATION (1GW11)

SOURCE: PHR & A, AUGUST 1995.

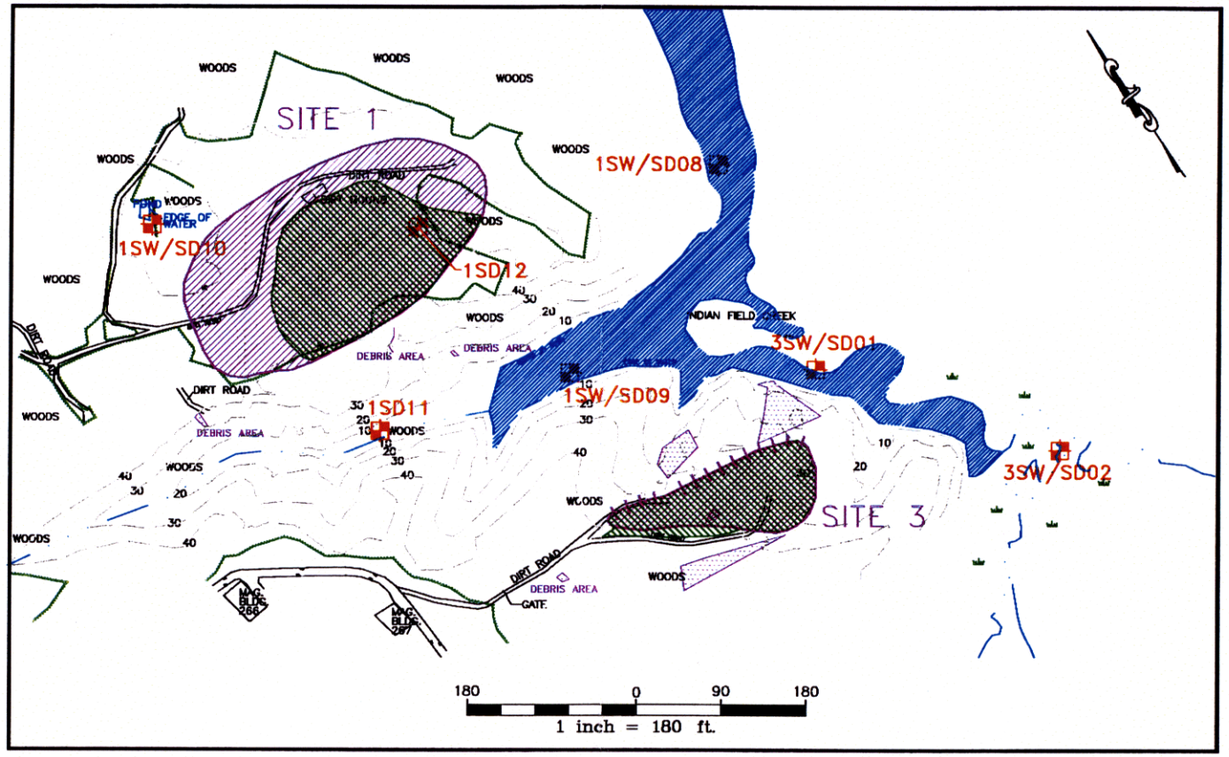
Baker Environmental, Inc.

FIGURE 1-7
ROUND ONE RI
SELECTED ANALYTICAL RESULTS FOR GROUNDWATER SAMPLES COLLECTED FROM SITES 1 AND 3
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

SITE 1	
1SD05-001	
10 J	Carbon Disulfide
66 J	Phenol
1SD05-002	
27 J	Carbon Disulfide
1SD06-001	
11 J	Carbon Disulfide
1SD06-101	
12 J	Carbon Disulfide
44 J	Phenol
110 J	Pentachlorophenol
1SD06-002	
24 J	Carbon Disulfide
1SD06-102	
9 J	Carbon Disulfide
52 J	Phenol
93 J	4-Methylphenol
1SD07-002	
13 J	Carbon Disulfide
1SD08-001	
34 J	Carbon Disulfide
230 J	Di-n-butylphthalate
1SD08-002	
250 J	Acetone
5 J	Carbon Disulfide
350 J	Di-n-butylphthalate

SITE 1	
1SD09-002	
7 J	Carbon Disulfide
1SD10-001	
40 J	Acetone
1SD10-002	
52 J	Acetone

SITE 3	
3SD01-001	
7 J	Carbon Disulfide
3SD02-001	
140 J	Phenol
400 J	4-Methylphenol
3SD02-002	
95 J	Acetone
99 J	Carbon Disulfide
50 J	Phenol



NOTES:

1. ELEVATIONS SHOWN WERE TAKEN FROM AN ALUMINUM RIVET LOCATED IN CONCRETE HEADWALL N. OF N. RD. TO AMMO OVERHAUL. BENCH MARK NUMBER MR-23 ELEVATION=44.11'
2. HORIZONTAL INFORMATION SHOWN WAS TAKEN FROM A DRAWING TITLED "HORIZONTAL SURVEYING CONTROL POINTS INDEX" BY TALBOT AND ASSOCIATES, LTD. CODE IDENT. NO. 80091 SHEET NUMBER I-7.
3. ANALYTICAL RESULTS REPORTED IN UNITS OF MICROGRAMS PER KILOGRAM (ug/kg).

LEGEND

- EDGE OF WATER
- TREELINE
- EDGE OF PAVEMENT
- BUILDING
- WETLANDS
- DEBRIS AREA
- REMEDIAL INVESTIGATION SITE
- SUSPECTED LIMIT OF SITE
- 3SW/SD01 ROUND ONE SURFACE WATER/ SEDIMENT LOCATION

SOURCE: PHR & A, AUGUST 1995.

Baker Environmental, Inc.

FIGURE 1-8
ROUND ONE RI
SELECTED ANALYTICAL RESULTS FOR SEDIMENT SAMPLES COLLECTED FROM SITES 1 AND 3
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

2.0 STUDY AREA INVESTIGATION

This section describes the Round Two field sampling activities conducted during the RI at Sites 1 and 3. The objectives of the study, individual media investigated, sampling procedures, and sampling locations are discussed. This section also discusses Quality Control (QC) procedures conducted during the sampling as well as management of the Investigation Derived Waste (IDW).

2.1 Introduction

The Round Two field program at Sites 1 and 3 was designed to provide information necessary to characterize potential human health effects and ecological impacts resulting from previous site activities. The following subsections present the sites and RI/FS objectives that will be used in the human health and ecological Risk Assessments (RAs) for each site.

Data gathered during the Round One RI indicated potential groundwater contamination within the area of monitoring well 1GW12 at Site 1 and in subsurface soil and groundwater at Site 3. However, the extent of potential contamination could not be defined. In addition, soil samples were collected from the 0- to 2-foot interval, which is no longer consistent with 0- to 6-inch soil samples used in human health risk assessments. Therefore, the field program conducted at Sites 1 and 3, under this investigation, was designed to further evaluate the extent of contamination in surface soil, subsurface soil, groundwater, surface water, sediment, and biota to provide data for human health and ecological risk assessments. Included in these objectives is to define the vertical extent of the buried debris at the landfill areas at both sites. Objectives of the RI/FS conducted for Sites 1 and 3 are summarized in Table 2-1.

2.2 Round Two Field Sampling Program

The field investigation at Sites 1 and 3 commenced in late January 1996 and continued until the mid February 1996. Groundwater monitoring wells were installed, test pits were excavated, and surface soil, subsurface soil, and groundwater samples were collected. Surface water, sediment, and biota samples were also collected within Indian Field Creek. These activities are outlined in the following subsections.

2.2.1 Soil Investigation

The soil investigation for Sites 1 and 3 included the collection of both surface and subsurface soil samples in accordance with the Final Work Plan for Sites 1 and 3 (Baker, 1996a). Surface soil samples were collected with stainless-steel spoons and subsurface soil samples were collected with a backhoe during the excavation of test pits or with a drill rig (split-spoon and shelby tube samplers) during the installation of monitoring wells. A summary of the surface soil sampling program at Sites 1 and 3, including sampling locations, the sampling date, and analytical parameters is provided in Table 2-2. Table 2-3 provides similar information for subsurface soils. Surface and subsurface soil sampling locations are presented in Figures 2-1 and 2-2, respectively.

2.2.1.1 Surface Soil Sampling

Surface (0- to 6-inch bgs) soil samples at Sites 1 and 3 were collected at monitoring well locations and throughout the landfill areas. The surface soil sample locations are presented on Figure 2-1. The surface soil were collected using stainless-steel sampling spoons; aluminum pie pans were used to composite the soil. The first inch of grass, matted roots, and /or humus material were removed prior to sample collection. The samples were placed in the appropriate containers and submitted for laboratory analysis. The samples were prepared according to USEPA Region III SOPs, Section 3.8 of the Final Master FSP (Baker, 1994a), and Section 4.1.1, and 4.2.1 of the Final Work Plan for Sites 1 and 3 (Baker, 1996).

The surface soil samples were analyzed for TCL semivolatile organics, nitramine compounds, pesticides/PCBs, TAL inorganics, and pH. Table 2-2 summarizes the analytical program for surface soil investigation.

Site 3 Confirmation Sampling

On August 26, 1996, six soil samples were collected to confirm the elevated SVOC concentrations detected in surface soil sample 3SS10 as shown on Figure 2-1. Five (3SS10A, 3SS10C through 3SS10F) of the samples were collected at the approximate location of 3SS10 at a spacing of 15 feet. One sample (3SB10B) was collected at the 3SS10A location at a depth of 1.5 - 2.0 ft. bgs.

All six of the samples were analyzed for TCL semivolatile organics as shown on Table 2-2.

2.2.1.2 Subsurface Soil Sampling

Subsurface (deeper than 6-inches bgs) soil samples were collected from soil borings and test pits to evaluate the horizontal and vertical extent of potentially impacted soil and for the RA evaluation purposes. Figure 2-2 presents subsurface soil sampling locations for Sites 1 and 3.

Soil borings

Subsurface soil borings were drilled at Sites 1 and 3 to collect subsurface soil samples and install monitoring wells for groundwater sampling. All soil borings, whether or not they were sampled for chemical analysis, were advanced using a split-spoon sampler and hollow-stem augers. Standard operating procedures (SOPs) for soil boring advancement and subsurface soil sampling are presented in the Final Master FSP (Baker, 1994a).

Seven boreholes, shown in Figure 2-2, were advanced at Site 1 to facilitate monitoring well installation and to further characterize the subsurface soil. Five of the soil borings (1SB/GW12A, 1SB/GW018, 1SB/GW19, 1SB/GW20, and 1SB/GW21) were advanced around 1GW12 (where organic solvents were detected in the shallow groundwater during previous investigations) to assess a relationship between the subsurface soil and groundwater. Four soil borings (1SB/GW21, 1SB/GW12A, 1SB/GW12B, and 1SB/GW13A) were advanced to facilitate deeper monitoring well (Type III) installation and to characterize the deeper subsurface soil. Two thin walled open (shelby) tube samples were collected during advancement of soil borings 1SB/GW12A and 1SB/GW13A. The samples were obtained within a thin discontinuous cohesive layer (63- to 65-feet bgs) at 1SB/GW12A and a low conductivity zone (11- to 13-feet bgs) corresponding to the Cornwallis Cave confining unit at 1SB/GW13A. The shelby tube samples were collected according to American Society for Testing and Materials (ASTM) Method D1587- 83 (04.08) (ASTM, 1983) and analyzed for vertical hydraulic conductivity, grain size (sieve and hydrometer), Atterberg limits, moisture content, specific gravity, pH and Eh. Additional information on site specific geology and hydrogeology and the results of the shelby tube testing are presented in Section 3.2.2.

Four boreholes, shown in Figure 2-2, were advanced at Site 3. All of the soil borings (3SB/GW08A, 3SB/GW15A, 3SB/GW19 and 3SB/GW19A) were advanced around the site to further characterize the subsurface soil. Soil borings 3SB/GW08A, 3SB/GW15A, and 3SB/GW19A were advanced to facilitate deeper monitoring well installation and to characterize the deeper subsurface soil.

From each of these borings, three soil samples were collected; one sample from the surface, one from the subsurface, and one from just above the top of the water table. The sampling protocols were described in Section 3.9 of the Final Master FSP (Baker, 1994a) and Sections 4.1.1 and 4.2.1 of the Final Work Plan for Sites 1 and 3 (Baker, 1995).

The subsurface soil samples were analyzed for TCL volatile organics, TCL semivolatile organics, nitramine compounds, pesticides/PCBs, TAL inorganics, and pH. Table 2-3 summarizes the analytical program for subsurface soil investigation.

Each split-spoon was classified visually by the on-site geologist. Lithological descriptions of the soil are provided on the Test Boring Records and Well Construction Records in Appendix 2A. Specific sampling and soil classification procedures are outlined in Sections 4.1.1 and 4.2.1 of the Final Work Plan for Sites 1 and 3 (Baker, 1995) and Section 3.9 of the Final Master FSP (Baker, 1994a) for WPNSTA Yorktown.

Soil cuttings and drilling water generated during the drilling program (i.e., IDW) were containerized and handled according to the procedures outlined in Section 2.8.

Shelby Tube sampling

Six thin walled open (shelby) tube samples were collected within the central portion of each landfill (both Sites 1 and 3) from depths of 0- to 2-feet bgs as shown on Figure 2-2 to determine the landfill cap composition. The samples were collected according to ASTM Method D 1587-83 (04.08) (ASTM, 1983) and analyzed for vertical hydraulic conductivity, grain size (sieve and hydrometer), Atterberg limits, moisture content, specific gravity, pH and Eh. Results of the analysis are presented in Section 3.2.2.

Test Pits

A total of eight test pits were excavated at Sites 1 and 3 to characterize and sample the subsurface soil, and to define the vertical extent of the buried material within the landfill areas. A summary of the locations and subsurface soil samples collected from the test pits are presented on Figure 2-2 and Table 2-3, respectively. The test pits were performed using level B personal protection and were excavated with a backhoe achieving depths of 3- to 9-feet bgs upon encountering natural soil. Test pitting activities were monitored by an ordnance subcontractor with geophysical instruments to direct the backhoe operator in location and depth of each bucket. Results of test pitting activities are presented in Section 4.0 and on Table 4-26. Test pit logs of the excavated trenches are presented in Appendix 2A.

2.2.2 Groundwater Investigation

The Round Two RI groundwater sampling program developed for Sites 1 and 3 was designed to determine if former site activities adversely impacted the quality of groundwater. Moreover, the program was developed to consider potential human health and ecological risks associated with the Contaminants of Potential Concern (COPCs).

In general, the field procedures and sampling methods employed for the groundwater investigation were implemented in accordance with USEPA Region III SOPs. These procedures also included sample handling and preservation, documentation, and chain-of-custody procedures. Specific sampling procedures are outlined in Section 4.2.2 of the Final Work Plan for Sites 1 and 3 (Baker, 1996) and Sections 3.14 and 3.15 of the Final Master FSP (Baker, 1994a) for WPNSTA Yorktown.

2.2.2.1 Monitoring Well Installation

As mentioned in Section 2.2.1.2, two types of monitoring wells were installed during this field program, Type II (shallow, no surface casing) and Type III (deep, surface casing) monitoring wells. Each type is briefly described in the following subsections; additional detail is located in Section 4.1.2. of the Final Work Plan for Sites 1 and 3 (Baker, 1996). Refer to Section 3.3 for a discussion of aquifers.

2.2.2.1.1 *Type II Monitoring Wells*

Three shallow Type II monitoring wells (1GW18, 1GW19 and 1GW20) were installed as shown on Figure 2-2 at Site 1 where a significant shallow groundwater unit (the equivalent of the Columbia Aquifer) was encountered. Groundwater was encountered at depths of 4- to 5-foot bgs and the total depth of the monitoring wells ranged from 10- to 18-feet bgs. Four (shallow and deep) monitoring wells (3GW08A, 3GW15A, 3GW19, and 3GW19A) were installed at Site 3, at the locations shown on Figure 2-2. Groundwater was encountered at depths ranging from 25- to 32-feet bgs and the total depth of monitoring wells ranged from 45- to 81-feet bgs. A shallow groundwater unit, similar to the one at Site 1, was not encountered when installing these wells; therefore, the wells were installed at greater depths and surface casing was not required. In addition, the depths of the wells were designed to monitor the upper and lower aquifer zones. Refer to the cross-sections in Section 3.0 for graphical depictions of monitoring well depths and their vertical positions within the aquifers at Sites 1 and 3.

Well construction details for the existing and newly installed type II wells are summarized on Table 2-4 and are shown on the Well Construction Records provided in Appendix 2A. Typical shallow monitoring well construction details are shown on Figure 2-3 for above ground completion. Specific monitoring well installation procedures are outlined in Sections 4.1.2 and 4.2.2 of the Final Work Plan for Sites 1 and 3 (Baker, 1995) and Sections 3.10 and 3.11 of the Final Master FSP (Baker, 1994a) for WPNSTA Yorktown.

2.2.2.1.2 Type III Monitoring Wells

Type III (i.e., outer casing installed) deep monitoring wells were installed only at Site 1 where a significant volume of shallow below ground surface groundwater was encountered. The groundwater extened to a maximum depth of 17 feet below ground surface where a cohesive soil layer inhibited downward flow. These wells were screened within the undivided Cornwallis Cave/Yorktown-Eastover aquifer using of hollow stem auger techniques and are shown on Figure 2-2.

Four type III monitoring wells (1GW12A, 1GW12B, 1GW13A and 1GW21) were installed at Site 1, and the well depths ranged from 40- to 75-feet bgs. Well construction details for the newly installed

deep wells are summarized on Table 2-4 and are shown on the Well Construction Records provided in Appendix 2A. The steel surface casing was installed a minimum of two feet into the Cornwallis Cave Confining unit to insure a proper seal between strata. This seal will mitigate the potential downward migration of perched groundwater along the borehole/well interface. The surface casing was grouted in place and allowed to set overnight. The borehole was then advanced through the 10-inch casing and the well was completed in the underlying Cornwallis Cave/Yorktown-Eastover aquifer. Subsequent monitoring well installation and construction procedures were the same as those employed for the shallow monitoring wells except that a bentonite slurry was placed above the sand pack in place of the bentonite pellets. The top of the sand pack remained at least two feet below the bottom of the confining unit. Typical Type III monitoring well construction details are shown on Figure 2-4 for above ground completion.

2.2.2.2 Well Development

Following well construction and curing of the bentonite and grout seals (i.e., 48 hours or more), each newly installed well was developed to remove fine-grained sediment from the screen and to establish interconnection between the well and the hydrogeological formation. The monitoring wells were developed by a combination of surging and bailing (with disposable polyethylene bailers) or pumping (Waterra or centrifugal above ground pumps). All equipment (i.e., bailers and polyethylene tubing) lowered down the monitoring wells were dedicated to that specific monitoring well and discarded following use. Specific well development procedures are outlined in Section 3.12 of the Final Master FSP (Baker, 1994a) and in Section 4.1.2.2 of the Final Work Plan for Sites 1 and 3 (Baker, 1996).

Measurements of pH, specific conductance, and temperature were recorded to assist in determining well stabilization. Well Development Forms summarizing this information are provided in Appendix 2B.

2.2.2.3 Groundwater Sampling

The following subsections describe the groundwater sampling procedures, and the analytical requirements for the groundwater samples collected. The samples were collected to confirm the presence or absence of contaminants and evaluate overall groundwater chemistry. Groundwater

samples were collected from seven newly installed monitoring wells, six existing monitoring wells at Site 1, and two existing wells at Site 11 for the Site 1 sampling program. Four newly installed and five existing monitoring wells were sampled at Site 3. Figure 2-2 shows the well locations. Groundwater sampling procedures, discussed below, were performed in accordance with USEPA Region III SOPs.

2.2.2.3.1 *Procedures*

Prior to groundwater purging, water levels from each well were measured and well volumes were calculated according to section 4.1.2.2 of the Final Master FSP (Baker, 1994a) for WPNSTA Yorktown. Following well volume calculations, a minimum of three to five well volumes were purged from each well prior to sampling. Water was purged from each well using either a disposable polyethylene bailer, a Waterra pump or a low flow peristaltic pump. Low flow pumping was utilized when the static water level within the monitoring well was less than 20-feet bgs. When the static water level was greater than 20-feet bgs purging was completed by using both bailers and the Waterra pump. Purge water was containerized and handled as described in Section 2.5 of this report. Section 4.2.2 of the Final Work Plan for Sites 1 and 3 (Baker, 1996) outlines the protocol for purging wells.

Groundwater samples were collected using either disposable polyethylene bailers dedicated to each monitoring well or a low flow pump with dedicated tubing. The samples were introduced into laboratory-prepared and certifies, preserved sample containers and stored on ice. Sample bottles for the VOC analysis were filled first, followed by SVOCs (including pesticides/PCBs and nitramines), TAL inorganics, and finally the engineering/water quality parameters. Samples analyzed for dissolved inorganics were filtered in the field or were collected in laboratory-prepared and certified bottles and filtered prior to placement in preserved bottles for shipment to the laboratory. The samples were filtered through a disposable 0.45 micron membrane. A peristaltic pump was used for the filtering procedure.

Preparation of groundwater samples incorporated procedures similar to those described for the other samples. Sample collection information, including well number, sample identification number, time, date, samplers, and analytical parameters, was recorded in the field logbook and on the sample labels. Chain-of-custody documentation accompanied the samples to the laboratory. Specific

sampling procedures are outlined in Section 4.2.2 in the Final Work Plan for Sites 1 and 3 (Baker, 1996) and Section 3.15 of the Final Master FSP (Baker, 1994a) for WPNSTA Yorktown. The analytical program for the groundwater investigation is summarized in Table 2-5.

2.2.2.4 Water Level Measurements and Surveying

Static water level measurements were collected twice during the field investigation from top-of-casing (TOC) reference points at each newly installed well and existing wells after they were developed. Measurements were also collected from the five staff gauges installed within Indian Field Creek and the small unfilled sand borrow pit at Site 1. Water level data was used to evaluate groundwater flow patterns (i.e., horizontal hydraulic gradient) and help estimate the groundwater/ surface water interaction at the site. Measurements were recorded using an electric measuring tape to the nearest 0.01-foot. The water level measurements were collected on February 12 and 14 and are presented in Table 2-6.

After drilling was completed, all on-site monitoring wells and staff gauges were surveyed to establish vertical elevation in relation to mean sea level (msl) and horizontal control. Vertical accuracy of each well (established to TOC at each well) was measured to 0.01 foot and horizontal accuracy to within 0.01 foot. Control was established by using horizontal and vertical control points near the site that are tied into the Virginia State Plan Coordinate System. A registered surveyor in Virginia (Patton, Harris, Rust, and Associates, P.E.) was retained to perform the survey. Specific procedures are outlined in Section 4.3.1 of the Final Work Plan for Sites 1 and 3 (Baker, 1996) and Sections 3.17 and 3.21 of the Final Master FSP (Baker, 1994a) for WPNSTA Yorktown.

2.2.2.5 In-Situ Hydraulic Conductivity Testing Procedures

In situ hydraulic conductivity tests ("slug tests") were performed in three monitoring wells at Site 1 and one monitoring well at Site 3 after the groundwater sampling was completed to determine aquifer hydraulic conductivity in the vicinity of the well. The tests were performed using solid PVC slugs and clean bailer rope. A pressure transducer attached to an electronic recording device (Hermit™ data logger) was used to record the test data. Two Type II monitoring wells (1GW18 and 1GW19), reflecting unconfined conditions, and one Type III monitoring well (1GW12A), reflecting confined conditions, were chosen for in situ hydraulic conductivity testing at Site 1. One deeper

Type II well (3GW19A) at Site 3 was chosen for hydraulic conductivity testing. The results of the slug tests are discussed in Section 3.3.2 and presented in Appendix 3A. Specific testing procedures are outlined in Section 3.16 of the Final Master FSP (Baker, 1994a) for WPNSTA Yorktown.

2.2.3 Surface Water, Sediment, and Biota Investigation

Surface water and sediment samples were collected in September 1995 to ensure that the surface water conditions are consistent with when the background samples (WPNSTA Background Report, Baker, 1995) were collected. A summary of the Site 1 and 3 surface water sampling program describing the sample designations, collection dates, and analytical parameters is provided in Table 2-7. A summary of the Site 1 and 3 sediment sampling program is provided in Table 2-8. Surface water and sediment locations are presented on Figure 2-5. The locations were chosen to coincide with the aquatic ecological sampling stations. Surface water and sediment field data forms are provided in Appendix 2C.

2.2.3.1 Surface Water

The data from surface water investigation conducted at Sites 1 and 3 within Indian Field Creek was used to assess potential impacts to the environment from Sites 1 and 3 and used in conjunction with the biota data in the ecological RA.

Five surface water and sediment sampling stations were identified to characterize the southern portion of Indian Field Creek (Figure 2-5). These sample locations were chosen to coincide with the aquatic ecological sampling described in Section 2.2.3.3. One surface water sample was collected from midstream at each sampling location except at 1SW/SD13 and 1SW/SD14 where the creek bed was dry therefore, only sediment samples were collected.

Samples were collected to represent surface water ambient conditions. Surface water was collected directly into a laboratory-supplied and certified sample bottle. The sample bottle was placed with the open end downstream to minimize collecting particulate matter or sediment in the water sample. All sample containers not containing preservative were rinsed at least once with the surface water prior to final sample collection. Downstream water samples were collected first, with subsequent

samples taken while moving upstream. Sediment samples were collected after the water samples to minimize sediment resuspension which might contaminate the water samples.

For those sample bottles that contained preservative (e.g., sulfuric acid, nitric acid, and sodium hydroxide), the water was collected in a clean, decontaminated laboratory sample bottle and then slowly transferred into the appropriate preservative-containing sample bottle.

After containerizing the volatile and semivolatile fractions the samples were filtered in the field through a disposable 0.45 micron membrane. A peristaltic pump was used for the filtering procedure. Sample preparation also included documentation of sample number, location, date, and time in a field logbook and on the sample labels. Chain-of-custody documentation accompanied the samples to the laboratory. Specific sampling procedures are outlined in Section 4.1.3 of the Final Work Plan for Sites 1 and 3 (Baker, 1996) and Section 3.7.1 of the Final Master FSP (Baker, 1994a) for WPNSTA Yorktown.

Table 2-7 summarizes the environmental samples to be collected and analytical parameters for the surface water samples. In addition, analyses for temperature, dissolved oxygen, salinity, specific conductivity, and turbidity (by Secchi disk) were performed (Appendix 2C, field data forms) on surface water samples in the field. The procedures for performing these measurements can be found in the Master FSP, Section 3.29 (Baker, 1994a).

2.2.3.2 Sediment

Sediment sampling was conducted at all five of the surface water/sediment sampling stations. A summary of the sediment sampling program, outlining the sample identification, collection date, sample interval, and analytical methods is provided in Table 2-8.

Surface (0- to 4-inches) and subsurface (4- to 8-inches) sediment samples were collected for chemical analysis with a sediment sleeve. The coring sleeve was pushed into the sediment to a depth of 12 inches or until refusal. The sediment samples were extruded with a decontaminated extruder into a laboratory-supplied and certified sampling bottle.

Sediment samples were prepared according to USEPA Region III SOPs. Following sample collection, each sample was stored on ice in a cooler. Sample preparation also included documentation of sample number, location, date, and time in a field logbook and on the sample labels. COC documentation accompanied the samples to the laboratory. Specific sampling procedures are outlined in Section 4.1.3 of the Final Work Plan for Sites 1 and 3 (Baker, 1996) and in Section 3.7 of the Final Master FSP (Baker 1994a) for WPNSTA Yorktown.

2.2.3.3 Biota Investigation

Aquatic ecological investigations were conducted at the three of the five surface water/sediment locations as shown in Figure 2-5. No water was present at stations 1SW/SD13 and 1SW/SD14 therefore samples were not collected. In general, the field procedures and sampling methods employed for the biota investigation were implemented in accordance with USEPA Region III SOPs. These procedures also included sample handling and preservation and documentation procedures. Specific sampling procedures are outlined in Section 4.1.4 for Site 1 of the Final Work Plan for Sites 1 and 3 (Baker, 1996) and Section 3.18 of the Final Master FSP (Baker, 1994a) for WPNSTA Yorktown.

Biota samples were collected from Indian Field Creek during the Round Two RI. Fish were collected with hoop nets, gill nets, dip nets, and cast nets. Benthic macroinvertebrate samples were collected with the Ponar grab sampler. Specific details on biota sampling at Sites 1 and 3 are provided in Section 7.4.

2.3 Quality Assurance/Quality Control Sampling Procedures

Field QA/QC samples were collected during the sampling program. These samples were obtained to: (1) ensure that decontamination procedures were properly implemented (i.e., equipment rinsate blanks); (2) evaluate field methodology (i.e., duplicate samples); (3) establish field background conditions (i.e., field blanks); and (4) evaluate whether cross-contamination occurred during sampling and/or shipping (i.e., trip blanks).

Several types of field QA/QC samples were collected and analyzed including duplicate samples, equipment rinsate blanks, field blanks, and trip blanks. A complete discussion of the QA/QC

procedures can be found in Section 8.0 of the Master Quality Assurance Project Plan (QAPP) (Baker, 1994c). The QA/QC Sampling Program for soil is outlined in Table 2-9; for groundwater in Table 2-10; for surface water on Table 2-11; for sediment in Table 2-12; and for all media in Table 2-13.

2.4 Decontamination Procedures

Decontamination procedures for heavy equipment (i.e., drilling augers), personnel, and sampling equipment were followed as per Section 3.25 of the Final FSP (Baker 1994a) for WPNSTA Yorktown. For sampling equipment, the decontamination procedures includes a soap and water wash with liquinox; rinse with deionized water; rinse with nitric acid; rinse with deionized water; and a final rinse with methanol before air drying. Heavy equipment decontamination included steam cleaning on a decontamination pad. Decontamination fluids were handled as outlined in Section 2.5 of this report.

2.5 Investigation Derived Waste Management

Solid (approximately 15 cubic yards) and liquid (approximately 3000 gallons) IDW was generated during the field program. Solids included soil cuttings and excess split-spoon samples; liquids included well development and purge water and decontamination fluids (i.e., water, liquinox soap solution, methanol, and 5 percent nitric acid solution).

Containerization and handling of solids were performed in two phases. At the completion of drilling, soil was temporarily placed into a backhoe bucket, then transported and emptied into the roll-off box for final containerization. A composite soil sample was collected from thje roll-off box and analyzed for full TCLP and Resource Conservation and Recovery Act (RCRA) hazardous waste characteristic analysis. The results indicated that the soil was non-hazardous therefore, the soil within the roll-off box was spread on site.

Liquids generated during the field program also were containerized and handled in two phases. Initially, development and purge water from each well and the heavy equipment decontamination water were placed in 55-gallon steel drums, then pumped into a tanker for final containerization. Decontamination water containing acids and solvents used for cleaning small sampling equipment

was also pumped into the tanker for final containerization. A composite water sample was collected from the tanker and analyzed for TCL volatile organics, TCL semivolatile organics, nitramine compounds, pesticides/PCBs, herbicides, TAL inorganics, cyanide, and RCRA characteristics. The results indicated that the water was non-hazardous therefore it was tranported off-site and disposed of at an off-site facility. Recomendations for solid and aquious IDW disposal are presented in Appendix 2D.

Items of personal protective equipment (PPE), such as disposable gloves, Tyvek, and disposable bailers were decontaminated, if appropriate, and double bagged in plastic bags and placed in the trash dumpster at Baker's Field Trailer. Specific procedures for decontamination are outlined in Section 4.6.2 of the Final Work Plan for Sites 6, 7, 12, 16 SSA 16, and Background (Baker, 1994) and Section 3.26 of the Final Master FSP (Baker, 1994) for WPNSTA Yorktown.

2.6 References

American Society for Testing and Materials (ASTM). 1983. Standard Practice for Thin-Walled Tube Sampling of Soils. ASTM Method D1587-83 (04.98), Annual Book of ASTM Standards, Philadelphia, Pennsylvania.

American Society for Testing and Materials (ASTM). 1984. Standard Method for Penetration Test and Split-Barrel Sampling of Soils. ASTM Method D1586-84, Annual Book of ASTM Standards, Philadelphia, Pennsylvania.

Baker Environmental, Inc. 1994a. Final Master Field Sampling Plan, Naval Weapons Station, Yorktown, Yorktown, Virginia. June 1994.

Baker Environmental, Inc. 1994b. Final Master Health and Safety Plan, Naval Weapons Station Yorktown, Yorktown, Virginia. June 1994.

Baker Environmental, Inc. 1994c. Final Master Quality Assurance Project Plans, Naval Weapons Station Yorktown, Yorktown, Virginia. June 1994.

Baker Environmental, Inc. 1996. Final Work Plan for Sites 1 and 3, Naval Weapons Station Yorktown, Yorktown, Virginia. March 1996.

Baker Environmental, Inc. 1995. Summary of Background Constituent Concentrations and Characterization of the Biotic Community from the York River Drainage Basin, Naval Weapons Station Yorktown, Yorktown, Virginia. March 1995.

United States Environmental Protection Agency. 1990. Macroinvertebrate Field and Laboratory Methods for Evaluating the Biological Integrity of Surface Waters. Office of Research and Development, Washington, D.C. EPA/600/4-90/030. November 1990.

TABLES

TABLE 2-1

RI/FS OBJECTIVES
SITES 1 AND 3
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Site and Medium of Concern	RI/FS Objective	Criteria for Meeting Objective	Investigation/Study
Sites 1 and 3 Soil	Confirm limited impacts to soil from past operations.	Determine contaminant levels in surface and subsurface soil.	Soil investigation
	Assess human health and ecological risks associated with exposure to surface soil.	Determine contaminant levels in surface and subsurface soil.	Soil investigation Risk assessment
	Assess areas of surface soil contamination resulting from site run-off.	Determine contaminant levels in surface soil at downgradient drainage areas.	Soil investigation
	Define vertical extent of buried debris in landfill areas.	Characterize the subsurface soil - determine natural soil horizon.	Soil investigation (Test Pitting)
Sites 1 and 3 Groundwater	Assess health risks posed by future usage of the shallow groundwater near Sites 1 and 3.	Evaluate groundwater quality and compare to regulatory criteria and health based action levels.	Groundwater investigation Risk assessment
	Define vertical and horizontal extent of groundwater contamination.	Characterize on-site groundwater quality in shallow and deeper portions of the aquifer.	Groundwater investigation
	Assess potential impact to groundwater from contaminated soil.	Characterize on-site groundwater quality.	Soil investigation Groundwater investigation
	Define hydrogeologic characteristics for fate and transport evaluations and remedial technology evaluation, if required.	Estimate hydrogeologic characteristics of the shallow aquifer (flow direction, transmissivity, permeability).	Groundwater investigation
Sites 1 and 3 Surface Water	Assess the presence or absence of surface water contamination in drainage ditches.	Determine surface water quality along drainage ditches.	Surface water investigation

TABLE 2-1

RI/FS OBJECTIVES
SITES 1 AND 3
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Site and Medium of Concern	RI/FS Objective	Criteria for Meeting Objective	Investigation/Study
Sites 1 and 3 Soil	Confirm limited impacts to soil from past operations.	Determine contaminant levels in surface and subsurface soil.	Soil investigation
	Assess human health and ecological risks associated with exposure to surface soil.	Determine contaminant levels in surface and subsurface soil.	Soil investigation Risk assessment
	Assess areas of surface soil contamination resulting from site run-off.	Determine contaminant levels in surface soil at downgradient drainage areas.	Soil investigation
	Define vertical extent of buried debris in landfill areas.	Characterize the subsurface soil - determine natural soil horizon.	Soil investigation (Test Pitting)
Sites 1 and 3 Groundwater	Assess health risks posed by future usage of the shallow groundwater near Sites 1 and 3.	Evaluate groundwater quality and compare to regulatory criteria and health based action levels.	Groundwater investigation Risk assessment
	Define vertical and horizontal extent of groundwater contamination.	Characterize on-site groundwater quality in shallow and deeper portions of the aquifer.	Groundwater investigation
	Assess potential impact to groundwater from contaminated soil.	Characterize on-site groundwater quality.	Soil investigation Groundwater investigation
	Define hydrogeologic characteristics for fate and transport evaluations and remedial technology evaluation, if required.	Estimate hydrogeologic characteristics of the shallow aquifer (flow direction, transmissivity, permeability).	Groundwater investigation
Sites 1 and 3 Surface Water	Assess the presence or absence of surface water contamination in drainage ditches.	Determine surface water quality along drainage ditches.	Surface water investigation

TABLE 2-1 (Continued)

RI/FS OBJECTIVES
SITES 1 AND 3
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Site and Medium of Concern	RI/FS Objective	Criteria for Meeting Objective	Investigation/Study
Sites 1 and 3 Sediment	Assess human health and ecological risks associated with exposure to contaminated sediment.	Characterize nature and extent of sediment contamination in drainage ditches.	Sediment investigation Risk assessment Biota Investigation
	Determine the extent of sediment contamination for purposes of identifying areas of remediation.	Identify extent of sediment contamination where levels exceed health based action levels.	Sediment investigation

TABLE 2-2

SUMMARY OF THE ROUND TWO RI SURFACE SOIL SAMPLING PROGRAM
SITES 1 AND 3
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Site	Sample Identification	Sample Interval (bgs)	Collection Date	Analytical Parameters
Site 1	1SS07	0-6"	01/24/96	TCL Semivolatile Organics, Pesticides/PCBs, Nitramine Compounds, TAL Inorganics
	1SS07D*	0-6"	01/24/96	
	1SS08	0-6"	01/24/96	
	1SS09	0-6"	01/24/96	
	1SS10	0-6"	01/23/96	
	1SS11	0-6"	01/23/96	
	1SS12	0-6"	01/23/96	
	1SS13	0-6"	01/23/96	
	1SS14	0-6"	01/23/96	
	1SS14D*	0-6"	01/23/96	
	1SS15	0-6"	01/23/96	
	1SS16	0-6"	01/23/96	
	1SS17	0-6"	01/23/96	
	1SS18	0-6"	01/23/96	
	1S12A-00	0-6"	01/24/96	
	1SB13A-00	0-6"	01/23/96	
	1SB13AD-00*	0-6"	01/23/96	
	1SB18-00	0-6"	01/24/96	
	1SB19-00	0-6"	01/23/96	
	1SB20-00	0-6"	01/23/96	
	1SB21-00	0-6"	01/24/96	

TABLE 2-2 (Continued)

SUMMARY OF THE ROUND TWO RI SURFACE SOIL SAMPLING PROGRAM
SITES 1 AND 3
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Site	Sample Identification	Sample Interval (bgs)	Collection Date	Analytical Parameters
Site 3	3SS04 3SS04D*	0-6" 0-6"	1/26/96	TCL Semivolatile Organics, Pesticides/PCBs, Nitramine Compounds, TAL Inorganics, pH
	3SS05	0-6"	1/26/96	
	3SS06	0-6"	1/26/96	
	3SS07	0-6"	1/26/96	
	3SS08	0-6"	1/26/96	
	3SS09	0-6"	1/26/96	
	3SS10	0-6"	1/26/96	
	3SS11 3SS11D*	0-6" 0-6"	1/30/96	
	3SS12	0-6"	1/29/96	
	3SS13	0-6"	1/29/96	
	3SS14	0-6"	1/30/96	
	3SB08A-00	0-6"	2/8/96	
	3SB15A-00	0-6"	1/29/96	
	3SB19A-00	0-6"	1/30/96	
Site 3 Confirmation Sampling	3SS10A	0-6"	8/26/96	TCL Semivolatile Organics
	3SB10B	1.5 - 2.0"	8/26/96	
	3SS10C	0-6"	8/26/96	
	3SS10D	0-6"	8/26/96	
	3SS10E	0-6"	8/26/96	
	3SS10F	0-6"	8/26/96	

TABLE 2-2 (Continued)

SUMMARY OF THE ROUND TWO RI SURFACE SOIL SAMPLING PROGRAM
SITES 1 AND 3
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Notes:

bgs - Below ground surface
* - Indicates duplicate sample
TAL - Target Analyte List
TCL - Target Compound List

TABLE 2-3

SUMMARY OF THE ROUND TWO RI SUBSURFACE SOIL SAMPLING PROGRAM
SITES 1 AND 3
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Site	Sample Identification	Collection Date	Sample Interval (feet, bgs)	Analytical Parameters
Site 1 Soil Borings	1SB12A-01	01/24/96	1-3	TCL Volatiles, TCL Semivolatiles, Pesticides/PCBs, Nitramine Compound, TAL Inorganics [1]
	1SB12AD-01*	01/24/96	1-3	
	1SB12A	01/24/96	15-19	Total Inorganic Carbon, Grain Size (sieve/hydrometer)
	1SB13A-01	01/25/96	1-3	
	1SB13AD-01*	01/25/96	1-3	
	1SB13A	01/25/96	33-37	Total Organic Carbon, Grain Size (sieve/hydrometer)
	1SB19-01	01/23/96	1-3	Total Organic Carbon, Grain Size (sieve/hydrometer)
	1SB19-02	01/23/96	3-5	
	1SB20-01	01/23/96	1-3	
	1SB21-06	01/24/96	11-13	
	1SB21-09	01/24/96	17-19	
Site 3 Soil Borings	3SB08A-04	02/08/96	7-9	
	3SB08AD-04*	02/08/96	7-9	
	3SB08A-09	02/08/96	17-19	
	3SB15A-08	01/29/96	15-17	
	3SB15A-12	01/29/96	23-29	
	3SB19A-07	02/07/96	13-15	
	3SB19A-14	02/07/96	27-29	
Site 1 Test Pits	1TP01	01/25/96	4-5	TCL Volatile Organics, TCL Semivolatile Organics, Pesticides/PCBs Nitramine Compounds, TAL Inorganics [1]
	1TP02	01/25/96	7-8	
	1TP03	01/25/96	7-8	
	1TP04	01/25/96	7-8	
	1TP04D	01/25/96	7-8	

TABLE 2-3 (Continued)

SUMMARY OF THE ROUND TWO RI SUBSURFACE SOIL SAMPLING PROGRAM
SITES 1 AND 3
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Site	Sample Identification	Collection Date	Sample Interval (feet, bgs)	Analytical Parameters
Site 3 Test Pits	3TP01	01/26/96	3-4	TCL Volatile Organics, TCL Semivolatile Organics, Pesticide/PCBs, Nitramine Compounds, TAL Inorganics(1)
	3TP02 3TP02D	01/26/96 01/26/96	8-9 8-9	
	3TP03	01/26/96	3-4	
	3TP04	01/26/96	3-4	

Notes:

bgs - Below ground surface
TAL - Target Analyte List
TCL - Target Compound List
TOC - Total Organic Carbon
* - Indicates duplicate sample
(1) - Analytical Parameters for all Samples

TABLE 2-4

SUMMARY OF WELL CONSTRUCTION DETAILS
SITES 1 AND 3
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Site	Well No.	Date Installed	Top of PVC Casing Elevation (feet, above msl)	Ground Surface Elevation (feet, above msl)	Boring Depth (feet, bgs)	Well Depth (feet,bgs)	Screen Interval Depth (feet, bgs)	Sand Pack Interval Depth (feet, bgs)	Bentonite Interval Depth (feet, bgs)	Lithology of Screened Interval	Hydro-geological Unit
1	1GW04	1/7/86	9.45	6.81	17	16.5	1.5-16.5	1.0-16.5	0-0.5	m-f sand to clayey sand	CA
	1GW05	12/11/85	36.59	34.80	16	15.5	0.5-15.5	0.5-15.5	0-0.5	silty sand to m-f sand	CA
	1GW12	6/10/92	45.24	42.90	14	14	4 -14	3-14	2-3	silty sand	CA
	1GW12A	1/26/96	43.34	41.4	65	64.5	49.5-64.5	46-65	43-46	shelly silt to sandy silt little shells	CCA/YEA
	1GW12B	1/29/96	41.48	40.70	38	38	28-38	25-38	23-25	shelly silt	CCA
	1GW13	6/10/92	43.52	40.8	14	14	4-14	3-14	2-3	silty sand	CA
	1GW13A	1/28/96	42.27	40.3	75	75	60-75	57-75	55-57	sandy silt ,trace shells	CCA/YEA
	1GW14	6/9/92	47.98	45.20	15	15	5-15	4-15	3-4	m-f sand to silty sand	CA
	1GW17	6/10/92	41.49	39.1	12	12	2-12	1-12	0.5-1.0	m-f sand to silty sand	CA
	1GW18	1/24/96	49.31	47.1	19	18	3-18	2-19	1-2	m-f sand	CA
	1GW19	1/23/96	45.96	43.56	15	13	3-13	2-15	1-2	silty fine sand	CA
	1GW20	1/23/96	27.29	24.9	13	10	5-10	3-10	1-3	m-f sand to sandy silt	CA
	1GW21	1/24/96	34.15	32.2	41	40	25-40	22-40	20-22	sandy silt, little shells	CCA

TABLE 2-4 (Continued)

SUMMARY OF WELL CONSTRUCTION DETAILS
SITES 1 AND 3
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Site	Well No.	Date Installed	Top of PVC Casing Elevation (feet, above msl)	Ground Surface Elevation (feet, above msl)	Boring Depth (feet, bgs)	Well Depth (feet,bgs)	Screen Interval Depth (feet, bgs)	Sand Pack Interval Depth (feet, bgs)	Bentonite Interval Depth (feet, bgs)	Lithology of Screened Interval	Hydro-geological Unit
Site 11	11GW11	6/11/92	44.50	41.80	12	12	4-12	3-12	2-3	m-f sand to silty sand	CA
	11GW11A	6/11/92	44.21	41.2	52	52	46-52	44-52	43-44	silty sand and shells	CCA
Site 3	3GW06	2/13/86	45.41	43.10	51	50	35-50	17-51	16-17	sandy silt to silty sand some shells	CCA
	3GW07	1/06/86	27.69	24.30	31	31	16-31	13-31	12-13	silty sand to m-f sand	CCA
	3GW08	1/07/86	28.78	26.10	32	32	17-32	14-32	13-14	silty sand	CCA
	3GW08A	2/08/96	27.99	25.90	75	75	60-75	57-75	53-57	silty sand, some shells	CCA/YEA
	3GW15	6/05/92	31.96	29.50	37	35	20-35	17-35	15-17	shelly clay to silty sand	CCA
	3GW15A	1/30/96	31.75	29.7	70	70	55-70	52-70	49-52	sandy silt, trace shells	CCA/YEA
	3GW18	6/03/92	48.39	46.2	51	50	35-50	33-50	31-33	silty sand, trace shells	CCA
	3GW19	2/07/96	39.51	37.10	45	45	30-45	27-45	23-27	sandy silt to silty sand, little shells	CCA
	3GW19A	2/05/96	39.62	37.30	84	81	66-81	63-81	60-63	silty sand, trace shells	CCA/YEA

Notes:

bgs = Below ground surface
msl = Mean sea level
CA = Columbia Aquifer
CCA = Cornwallis Cave Aquifer
Horizontal positions are referenced to Virginia State Plan Coordinate System.
CCA/YEA = Cornwallis Cave and Yorktown-Eastover Aquifers Combined

TABLE 2-5

SUMMARY OF HYDROPUNCH/TEMPORARY AND PERMANENT MONITORING WELL GROUNDWATER SAMPLING PROGRAM SITES 1 AND 3 NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA

Site	Sample Identification	Collection Date	Analytical Parameters
Site 1	1GW04-01	02/12/96	TCL Volatile Organics, TCL Semivolatile Organics, Nitramine Compounds, TAL Inorganics (total and dissolved), Pesticides/PCBs, Nitrate/Nitrite, TDS/TSS, TKN, Ammonia
	1GW04D-01	02/12/96	
	1GW05-01	02/12/96	
	1GW12-01	02/09/96	
	1GW12A-01	02/12/96	
	1GW12B-01	02/12/96	
	1GW13-01	02/12/96	
	1GW13A-01	02/12/96	
	1GW13AD-01	02/12/96	
	1GW14-01	02/08/96	
	1GW17-01	02/08/96	
	1GW18-01	02/09/96	
	1GW19-01	02/09/96	
	1GW20-01	02/12/96	
	1GW21-01	02/12/96	
	1GW11-01	02/12/96	
	1GW11A-01	02/12/96	

TABLE 2-5 (Continued)

SUMMARY OF HYDROPUNCH/TEMPORARY AND PERMANENT MONITORING WELL
GROUNDWATER SAMPLING PROGRAM
SITES 1 AND 3
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Site	Sample Identification	Collection Date	Analytical Parameters
Site 3	3GW06-01 3GW06D-01	02/11/96 02/11/96	TCL Volatile Organics, TCL Semivolatile Organics, Nitramine Compounds, TAL Inorganics (total and dissolved), Pesticides/PCBs, Nitrate/Nitrite, TDS/TSS, TKN, Ammonia
	3GW07-01	02/11/96	
	3GW08-01 3GW08A-01	02/11/96 02/12/96	
	3GW15-01 3GW15A-01	02/12/96 02/11/96	
	3GW18-01 3GW18D-01	02/11/96 02/11/96	
	3GW19-01 3GW19A-01	02/11/96 02/11/96	

Notes:

* - Indicates duplicate sample
TAL - Target Analyte List
TCL - Target Compound List
TDS - Total dissolved solids
TSS - Total suspended solids
TKN - Total Kjeldahl Nitrogen

TABLE 2-6

SUMMARY OF WATER LEVEL MEASUREMENTS
SITES 1 AND 3
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Monitoring Well	Date	Static Water Level (feet below top of PVC)	Water Level Elevation (feet above msl)	Date	Static Water Level (feet below top of PVC)	Water Level Elevation (feet above msl)
1GW04	2/12/96	5.26	4.28	2/14/96	5.14	4.40
1GW05	2/12/96	2.02	34.57	2/14/96	2.08	34.51
1GW12	2/12/96	7.09	39.15	2/14/96	7.16	38.08
1GW12A	2/12/96	30.51	12.83	2/14/96	30.36	12.98
1GW12B	2/12/96	28.34	13.5	2/14/96	28.14	13.70
1GW13	2/12/96	7.04	36.50	2/14/96	7.19	36.33
1GW13A	2/12/96	35.39	6.88	2/14/96	35.10	7.17
1GW14	2/12/96	8.51	39.47	2/14/96	8.45	39.53
1GW17	2/12/96	4.01	37.48	2/14/96	4.09	37.40
1GW18	2/12/96	10.31	39.00	2/14/96	9.24	40.07
1GW19	2/12/96	7.15	38.81	2/14/96	7.18	38.78
1GW20	2/12/96	7.71	19.58	2/14/96	7.63	19.66
1GW21	2/12/96	19.80	14.35	2/14/96	19.71	14.44
11GW11	2/12/96	7.05	37.45	2/14/96	7.10	37.40
11GW11A	2/12/96	25.62	18.59	2/14/96	25.51	18.70
1SG01	2/12/96	1.62	0.62	2/14/96	2.00	1.3
1SG02	2/12/96	2.67	0.77	2/14/96	1.89	1.55
1SG03	2/12/96	2.99	0.24	2/14/96	2.21	1.02
1SG04	2/12/96	1.72	0.14	2/14/96	1.36	1.02
1SG05	2/12/96	1.36	38.71	2/14/96	1.34	38.71

TABLE 2-6 (Continued)

SUMMARY OF WATER LEVEL MEASUREMENTS
SITES 1 AND 3
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Monitoring Well	Date	Static Water Level (feet below top of PVC)	Water Level Elevation (feet above msl)	Date	Static Water Level (feet below top of PVC)	Water Level Elevation (feet above msl)
3GW06	2/12/96	37.96	7.45	2/14/96	37.81	7.60
3GW07	2/12/96	22.06	5.63	2/14/96	22.02	5.67
3GW08	2/12/96	24.24	4.54	2/14/96	24.16	4.62
3GW08A	2/12/96	23.68	4.31	2/14/96	23.07	4.92
3GW15	2/12/96	26.66	5.30	2/14/96	26.59	5.37
3GW15A	2/12/96	24.80	6.95	2/14/96	24.73	7.02
3GW18	2/12/96	37.51	10.88	2/14/96	37.27	11.12
3GW19	2/12/96	34.74	4.77	2/14/96	34.63	4.88
3GW19A	2/12/96	34.54	5.08	2/14/96	34.39	5.23

Notes:

msl = Mean sea level
PVC = Polyvinyl Chloride (pipe)

TABLE 2-7

SUMMARY OF THE ROUND TWO RI SURFACE WATER SAMPLING PROGRAM
SITES 1 AND 3
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Site	Sample	Collection Date	Analytical Parameters
Sites 1 and 3	1SW15		TCL Volatile Organics, TCL Semivolatile Organics, TAL Inorganics (total and dissolved), Pesticides/PCBs, Hardness, TOC
	1SW16 1SW16D		
	1SW17		

Notes:

* - Indicates duplicate sample
TAL - Target Analyte List
TCL - Target Compound List
TOC - Total Organic Carbon

TABLE 2-8

SUMMARY OF THE ROUND TWO RI SEDIMENT SAMPLING PROGRAM
SITES 1 AND 3
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Site	Sample Identification	Collection Date	Sample Interval (feet, bgs)	Analytical Parameters
Site 9	1SD13-01 1SD13-02		0-4 4-8	TCL Volatile Organics, TCL Semivolatile Organics, TAL Inorganics, Pesticides/PCBs, pH, TOC, Grain Size
	1SD14-01 1SD14-02		0-4 4-8	
	1SD15-01 1SD15-02		0-4 0-8	
	1SD16-01 1SD16D-01 1SD16-02		0-4 0-4 4-8	
	1SD17-01		0-4	

Notes:

bgs - Below ground surface
TCL - Target Compound List
TAL - Target Analyte List
TOC - Total Organic Carbon
* - Indicates duplicate sample

FIGURES

318720WP

CONFIRMATION SOIL SAMPLING FOR
LOCATION 3SS10
AUGUST 26, 1996

SCALE: 1"=80'

SITE 1

SITE 3

1SS07
1SS08
1SS10
1SS13
1SS16
1SS17
1SS12
1SS15
1SS18
1GW18
1GW19
1SS14
1SS11
1GW12A
1GW13A
1GW21
1GW20
DEBRIS AREA
DEBRIS AREA
DEBRIS AREA
3SS11
3GW19A
3GW08A
3SS14
3GW15A
3SS13
3SS10
3SS12
3SS09
3SS05
3SS07
3SS06
3SS08
3SS04
DEBRIS AREA
3SS10E
3SS10A
3SB10B
3SS10C
3SS10F
3SS10D
INDIAN FIELD CREEK
EDGE OF WATER
DIRT ROAD
DIRT MOUND
POND
WOODS
MAG. BLDG. 266
MAG. BLDG. 267
GATE

180 0 90 180
1 inch = 180 ft.

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Baker Environmental, Inc.

NOTES:

1. ELEVA
LOCA
OVER

2. HORIZ
DRAW
INDEX
8009

3. ADDITI
EACH

TIONS SHOWN WERE TAKEN FROM AN ALUMINUM RIVET
TED IN CONCRETE HEADWALL N. OF N. RD. TO AMMO
HAUL. BENCH MARK NUMBER MR-23 ELEVATION=44.11'

ONTAL INFORMATION SHOWN WAS TAKEN FROM A
ING TITLED "HORIZONTAL SURVEYING CONTROL POINTS
" BY TALBOT AND ASSOCIATES, LTD. CODE IDENT. NO.
1 SHEET NUMBER 1-7.

ONAL SURFACE SOIL LOCATIONS ARE ASSOCIATED WITH
OF THE SUBSURFACE SOIL LOCATIONS ON FIGURE 4-2.

LEGEND

- EDGE OF WATER
- TREELINE
- EDGE OF PAVEMENT
- BUILDING
- WETLANDS
- DEBRIS AREA
- REMEDIAL INVESTIGATION SITE

3SS04 – SURFACE SOIL SAMPLE LOCATION

3SB10B – SUBSURFACE (1.5 TO 2.0 FT) SOIL SAMPLE LOCATION

1GW19 – SURFACE SOIL SAMPLE AT MONITORING WELL LOCATION

NOTE: SURFACE SOIL SAMPLES WERE COLLECTED AT SELECT SOIL BORING LOCATIONS.

SOURCE: PHR & A, AUGUST 1995.

FIGURE 2-1
SURFACE SOIL SAMPLING LOCATIONS
SITES 1 AND 3
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

318721WP

WOODS

WOODS

WOODS

1GW13A

1GW13

1GW17

SITE 1

WOODS

TEST PIT #1/01

DIRT ROAD

1ST04

POND

WOODS

DIRT MOUND

TEST PIT # 1/02

WOODS

1GW05

WOODS

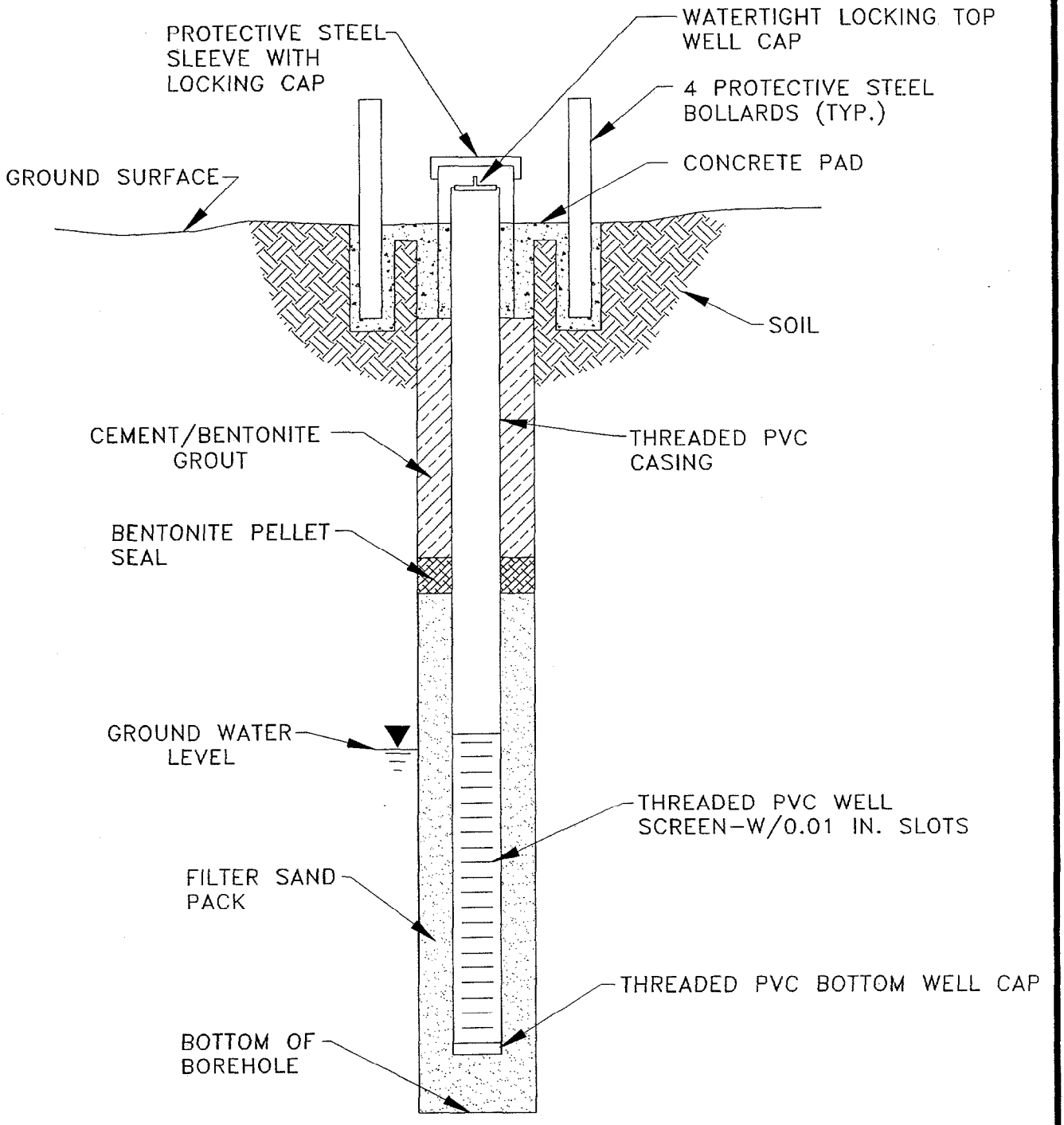
TEST PIT #1/03

40

1ST05

40

30



N.T.S.

Baker
Baker Environmental, Inc.

FIGURE 2-3
TYPICAL SHALLOW GROUNDWATER MONITORING WELL
CONSTRUCTION DIAGRAM - ABOVE GRADE SURFACE COMPLETION
SITES 1 AND 3

NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA

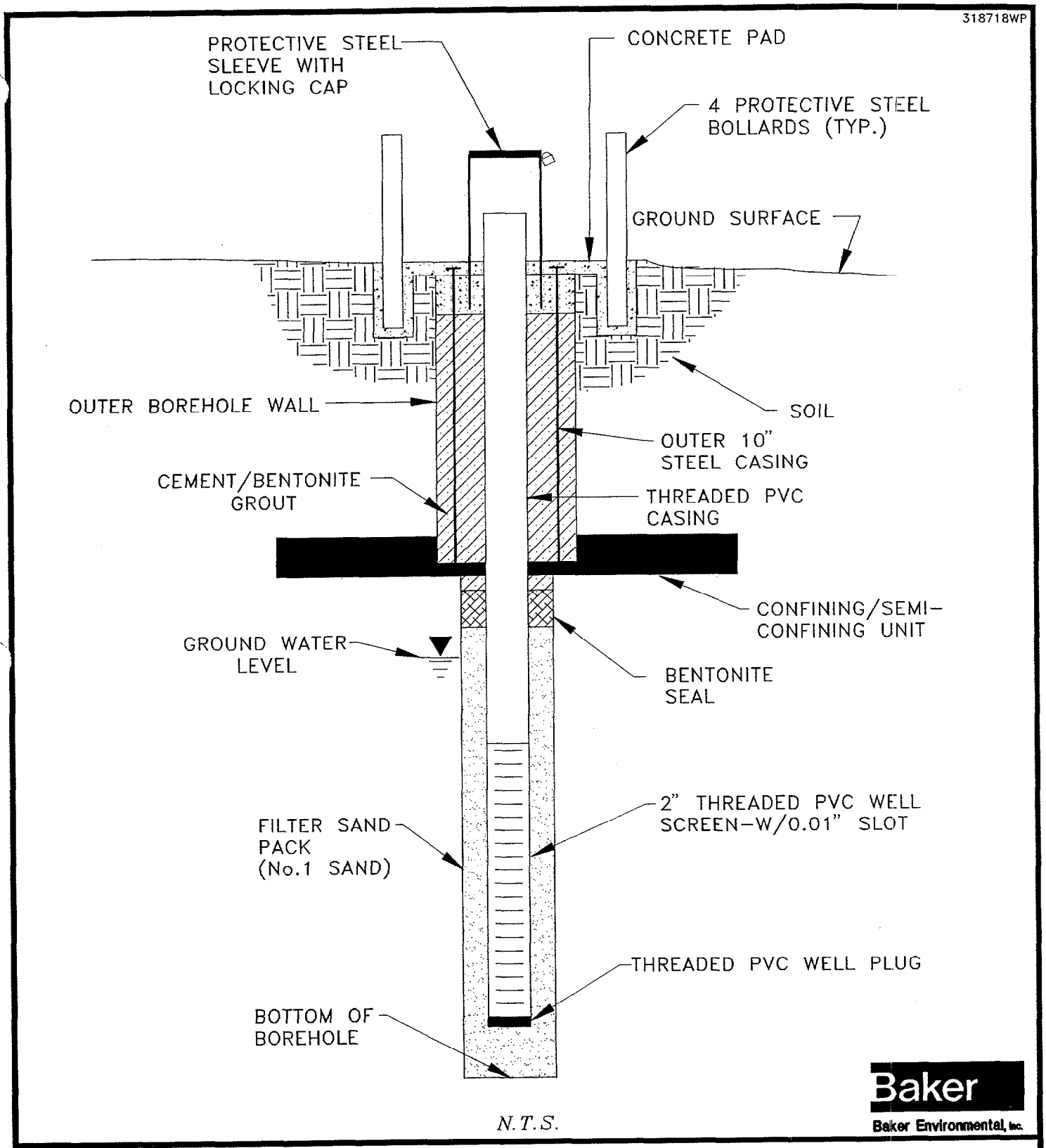
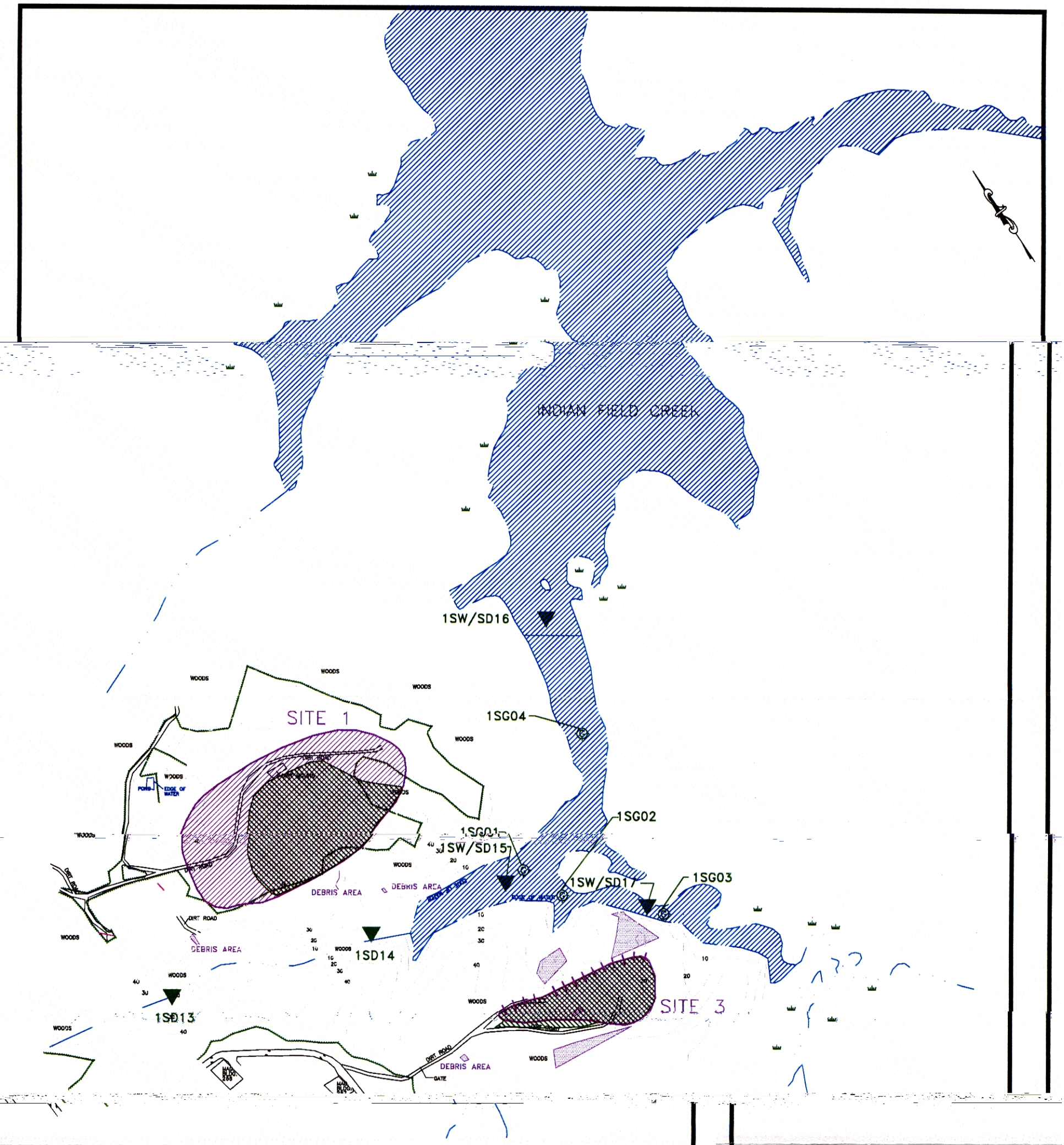


FIGURE 2-4
TYPICAL DEEP GROUNDWATER MONITORING WELL
CONSTRUCTION DIAGRAM - ABOVE GRADE SURFACE COMPLETION
SITES 1 AND 3

NAVAL WEAPONS STATION YORKTOWN

YORKTOWN, VIRGINIA



ROM AN ALUMINUM RIVET
N. OF N. RD. TO AMMO
R MR-23 ELEVATION=44.11'

WAS TAKEN FROM A
VEYING CONTROL POINTS
S, LTD. CODE IDENT. NO.

NOTES:

1. ELEVATIONS SHOWN WERE TAKEN FI
LOCATED IN CONCRETE HEADWALL
OVERHAUL. BENCH MARK NUMBER

2. HORIZONTAL INFORMATION SHOWN W
DRAWING TITLED "HORIZONTAL SURV
INDEX" BY TALBOT AND ASSOCIATES
80091 SHEET NUMBER 1-7.

300 0 150 300
1 inch = 300 ft.

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318719WP

LEGEND

- SUSPECTED LIMIT OF SITE
- EDGE OF WATER
- TREELINE
- BUILDING
- WETLANDS
- DEBRIS AREA
- REMEDIAL INVESTIGATION SITE

1SW/SD17 - ROUND TWO RI SURFACE WATER/SEDIMENT/ BENTHIC/FISH SURVEY LOCATION

1SG01 - STAFF GAUGE LOCATION

SOURCE: PHR & A, AUGUST 1995.

FIGURE 2-5

ROUND TWO RI
SURFACE WATER, SEDIMENT, AND BIOTA
SAMPLE LOCATIONS - SITES 1 AND 3

NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

3.0 PHYSICAL CHARACTERISTICS OF THE STUDY AREA

This section presents a summary of information regarding the environmental setting of the Station including geography, meteorology, surface water hydrology, soil, geology, hydrogeology, land use, and demography. Additional information on the environmental setting is found in the Summary of Background Constituent Concentrations and Characterization of the Biotic Community from the York River Drainage Basin (Baker, 1995).

3.1 General Physiography

WPNSTA Yorktown is located in the southeast portion of Virginia on the York-James Peninsula. The local terrain is gently rolling and the land is dissected by ravines and stream valleys.

The climate of WPNSTA is maritime with mild winters and long, warm, humid summers. Prevailing winds are usually from the south-southwest. The average precipitation during the investigation at Sites 1 and 3 (late January to mid-February) was 5.5 inches.

WPNSTA is situated within two major drainage basins of the York and the James Rivers. Sites 1 and 3 are located adjacent to the southern portion of Indian Field Creek within the York River Basin. Within the York River Basin, four tributaries (King Creek, Felgates Creek, Indian Field Creek, and Ballard Creek) drain the northern and eastern portions of the Station.

The general topography of Site 1 is level (near the landfill area) with a slight slope to the east and more pronounced slopes at the eastern and southern portions of the site toward Indian Field Creek. Ground surface elevations range from approximately 45 feet above msl at the western portion of the site near 1GW14 to approximately 4 feet above msl at the eastern portion of the site adjacent to Indian Field Creek. The majority of surface water would also drain toward Indian Field Creek. A small portion of the surface water recharges the small unfilled sand borrow pit at the northwest portion of the site between 1GW14 and 1GW17. The water levels within the pond fluctuates seasonally from a few inches during dry periods to approximately 2 feet during the rainy seasons.

The general topography of Site 3 can be described as hummocky (uneven) with the topographic highs (46 feet and 37 feet above sea level) near 3GW18 and 3GW19, and topographic lows

(excluding the areas adjacent to Indian Field Creek) within the landfill (30 feet above msl) and near 3GW07 at 24 feet above msl. The surface water would flow toward the landfill and the area around 3GW07 and 3GW08 where surface water was observed to accumulate before infiltration into the subsurface. Surface water would also flow to Indian Field Creek from the topographic high near 3GW19 and two drainageways to the east and west of this location.

3.2 Geology

The following sections contain a summary of the regional geology of WPNSTA Yorktown and the site-specific geology of Sites 1 and 3. Additional details on the regional geology are found in the Background Report (Baker, 1995).

3.2.1 Regional Geology

The Atlantic Coastal Plain physiographic province is underlain by unconsolidated sediments of Quaternary, Tertiary, and Cretaceous ages (see Figures 3-1 and 3-2) that dip gently to the southeast and have a combined thickness of approximately 1,900 feet in the vicinity of WPNSTA Yorktown (Teifke, 1973).

Most of the surficial unconsolidated sediments at WPNSTA Yorktown have been mapped as the Windsor Formation of the Pleistocene series (Johnson, 1972; Mixon et al., 1989a). This formation is composed of a series of sand and silt deposited in marine and estuarine environments. Its thickness is estimated to vary from 0- to 40-feet at WPNSTA Yorktown. The Bacons Castle Formation of Pliocene age underlies the Windsor Formation and is described as a clayey silt and silty fine-grained sand. The unit rests unconformably on the weathered top of the Upper Yorktown Formation, also of Pliocene age. The presence of calcite-cemented shells and shell fragments is characteristic of the upper portion of the Yorktown Formation. This type of lithology was encountered during the Station Background Investigation (Baker, 1995) and during this investigation.

3.2.2 Sites 1 and 3 Geology

Nine soil borings were advanced within the vicinity of Sites 1 and 3 to characterize the subsurface soil conditions, collect soil samples for laboratory analysis, collect groundwater samples, and for monitoring well installation. In general, the site is underlain by unconsolidated deposits of coarse to fine-grained sand with silt, silt and clay, and sand, silt, and marine shells. These findings were consistent with subsurface soil data from the thirteen existing soil borings for monitoring wells completed by Dames & Moore during Round One of the Confirmation Study at WPNSTA Yorktown (Dames & Moore, 1986) and by Roy F. Weston for the Round One RI (Baker, 1992).

The surficial strata at Sites 1 and 3 are generally characterized by medium to fine grained sands with varying amounts of silt and trace amounts of clay and gravel. These deposits make up the surficial aquifer (Columbia) at Site 1, but this hydrogeological unit is absent at Site 3 although the deposits are similar in nature. This is consistent with the hydrogeology described by Weston during the Round One RI. Underlying this strata are cohesive deposits of silts and clays that act as a confining/semiconfining unit and is the equivalent of the Cornwallis Cave confining unit. A composite sample (ISBRA) collected from 15- to 19-feet bgs within the Cornwallis Cave confining unit was analyzed for grain size. A hydraulic conductivity of 7.7×10^{-3} ft/day was calculated from the grain size results and is presented at the end of Appendix 3A. Underlying these deposits, a stratum containing sand, silt, and marine shell fragments (Cornwallis Cave aquifer) was encountered. This unit is the lower confined aquifer at Site 1, but is the surficial aquifer at Site 3. This unit becomes slightly coarser grained with depth becoming more sandy with a smaller percentage of shell fragments resembling the Yorktown-Eastover aquifer. In addition, the thickness of the strata is greater than the descriptions previously noted during past Baker field investigations. This is an example of where the Yorktown confining unit is absent (possibly eroded by the York River) and the two hydrogeological units (Cornwallis Cave and Yorktown-Eastover aquifers) combine into a single aquifer. These units were consistent with descriptions of the Columbia aquifer, Cornwallis Cave confining unit, and the Cornwallis Cave, and the Yorktown-Eastover aquifer (undivided) as defined by Brockman and Richardson (1992). The Test Boring Records are provided in Appendix 2A.

Cross-sections depicting the subsurface geologic conditions underlying the site were developed based on information obtained during the drilling program. As shown on Figure 3-3, four

cross-sections at the site were traversed. In general, cross-section A to A' (Site 1, Figure 3-4) traverse northwest to southeast, cross-section B to B' (Sites 1 and 3, Figure 3-5) traverse southwest to northeast, cross-section C to C' (Site 3, Figure 3-6) traverse south to northeast, and cross-section D to D' (Sites 1 and 3, Figure 3-7) traverse north to south.

During the field investigation, eight thin-walled (Shelby) tube samples were collected within two soil borings at Site 1 and within the landfill caps at both sites. The samples were analyzed for grain size (sieve/hydrometer), Atterberg limits, hydraulic conductivity, moisture content, specific gravity, pH and Eh.

One shelby tube sample was collected at 1SB/GW12 at a depth of 63 to 65 feet bgs. The sample was collected within a discontinuous semiconfining layer of very fine grained sand and silt. The test results classified (via the Unified Soil Classification System) the soil as SM, fine grained silty sand. The hydraulic conductivity of the sample could not be was determined through physical testing due to the granular nature of the sample but it was estimated to be within the range of 10^{-3} to 10^{-5} centimeters per second (cm/sec) or 10 to 10^{-1} ft/day. This is the range of hydraulic conductivities for silty sand deposits determined by Fetter (1988). The second shelby tube sample was collected at 1SB/GW13A at a depth of 11 to 13 feet bgs. The sample was collected within the Cornwallis Cave confining unit below the Columbia aquifer. The test results classified the soil as CH, inorganic clays of high plasticity. The hydraulic conductivity of the sample was determined to be 7.5×10^{-8} cm/sec (2.1×10^{-4} ft/day) which is within the range of hydraulic conductivity for marine clay (Fetter, 1988).

Results of the remaining shelby tube samples classify the soil cap at the Site 1 landfill ranging from silty sand (SM) to clayey sand (SC) with the hydraulic conductivity ranging from 1.0×10^{-3} cm/sec to 9.4×10^{-7} cm/sec (10 ft/day to 2.7×10^{-3} ft/day). The soil cap at the Site 3 landfill ranged in classification clayey sands (SC) to clay (CH) with hydraulic conductivities ranging from 1.3×10^{-6} cm/sec to 1.9×10^{-7} cm/sec (3.7×10^{-3} ft/day to 5.4×10^{-4} ft/day).

Test results for all the shelby tube samples are presented in Appendix 3A.

3.3 Hydrogeology

3.3.1 WPNSTA Yorktown

The following section summarizes the hydrogeology of the Station. Additional hydrogeological details are found in the Background Report (Baker, 1995).

The Atlantic Coastal Plain sediments are the most important source of potable water in the region. Recharge to the groundwater system is derived from precipitation. Approximately 50 percent of the precipitation is lost to evapotranspiration. The remaining 50 percent either results in surface runoff or infiltrates and is introduced into the groundwater regime. Recharge of aquifers may occur at the surface near outcrop zones, or from downward migration from overlying strata (Baker, 1994).

The shallow aquifer system in York County is comprised of the following seven units: (1) the undivided York County shallow aquifer system, (2) the Columbia aquifer, (3) the Cornwallis Cave confining unit, (4) the Cornwallis Cave aquifer, (5) the Yorktown confining unit, (6) the Yorktown-Eastover aquifer, and (7) the Eastover-Calvert confining unit (Brockman and Richardson, 1992). These hydrogeologic units and their relation to the geologic units are listed in Figure 3-1.

The undivided York County shallow aquifer system exists where one or more of the confining units commonly present in other areas of the county is absent (typically adjacent to the York River), and two or more aquifers form one hydraulic unit. The Columbia aquifer consists of sandy deposits which exist under unconfined (water table) conditions. Clayey or silty sediments typically comprise the Cornwallis Cave confining unit which underlie the Columbia aquifer. Most of the county is underlain by this aquifer and confining unit, but the units are missing in areas of western and west-central York county and in a narrow band along the York River. The Cornwallis Cave aquifer consists of sandy and shelly sediments and is defined by the water table (where unconfined). This unit is usually distinguished by the shelly deposits of the Yorktown Formation. The Yorktown confining unit which underlies the Cornwallis Cave aquifer is comprised of clays and silts and is usually distinguishable by its dark greenish gray color. The Yorktown-Eastover aquifer underlies the Yorktown confining unit, which is comprised of sandy and shelly sediments which is typically confined, but locally may be unconfined (e.g., adjacent to the York River, provides the source of

water for some of the domestic supply wells in the county. The basal unit within the York County shallow aquifer system is the Eastover-Calvert confining unit, which consists of silt and clay.

3.3.2 Site Hydrogeology

As described in Section 3.2, the shallow subsurface portion of the site is characterized by unconsolidated deposits of medium to fine grained sand, clayey silt, silt with marine shell fragments, and fine-grained sand which is generally consistent with the shallow hydrogeological framework described by Brockman and Richardson (1992). Collectively, these units form the shallow aquifer system at Sites 1 and 3 and correspond to the Columbia aquifer, Cornwallis Cave confining unit, and Cornwallis Cave/Yorktown-Eastover aquifer. Labeling of the lower hydrogeological unit at Site 1 and the surficial hydrogeological unit at Site 3 the Cornwallis Cave/Yorktown-Eastover aquifer is not accepted geological nomenclature. This unit was labeled the Cornwallis Cave/Yorktown-Eastover aquifer for the purposes of this report to describe a variation of the lower hydrogeological units of the Yorktown shallow aquifer system (Cornwallis Cave aquifer, Yorktown confining unit and the Yorktown-Eastover aquifer) where the Yorktown confining unit appears to be eroded combining the two lower aquifers. Therefore, to collectively describe the thicker unit both aquifer names were used. The Columbia aquifer is present at Site 1 but is absent at Site 3.

The monitoring wells installed (previously and currently) within the Columbia aquifer at Site 1 and the vicinity are 1GW04, 1GW05, 1GW13, 1GW14, 1GW17, 1GW18, 1GW19, 1GW20 and 11GW11. These wells ranged in depth from 10-feet bgs (11GW11) to 18-feet bgs (1GW18) and were screened within deposits of silty sand to medium to fine grained sand. Five monitoring wells (1GW12A, 1GW12B, 1GW13A, 1GW21, and 11GW11A) were installed at the site within the deeper confined (Cornwallis Cave/Yorktown-Eastover) aquifer, which consisted of sand, silt, and marine shell fragments. These monitoring wells ranged in depth from 38-feet bgs (1GW12B) to 75-feet bgs (1GW13A). A summary of well construction details is presented on Table 2-4. Groundwater level measurements were obtained from the existing and newly installed monitoring wells throughout the investigation. These data are presented on Table 2-6.

All of the monitoring wells installed (previously and currently) at Site 3 were set within the undivided Cornwallis Cave/Yorktown-Eastover aquifer which consisted of sand, silts, clays, and marine shell fragments. The wells were set within the upper portion of the aquifer and the lower

portion of the aquifer. The depths ranged 30-feet bgs (3GW06) to 81-feet bgs (3GW19A) and were similar to the depths of the deep monitoring wells at Site 1. A summary of well construction details is presented on Table 2-4. During the drilling program, groundwater was encountered at approximately 25- to 32-feet bgs. Groundwater level measurements were obtained from the existing and newly installed monitoring wells throughout the investigation. These data are presented on Table 2-6.

Potentiometric surface (contour) maps depicting the horizontal groundwater flow patterns within the shallow aquifer at Site 1 and the surficial portion of the aquifer at Site 3 on February 14, 1996 are presented on Figures 3-8 and 3-9 respectively. As shown on these figures, groundwater flow for both sites is toward Indian Field Creek with the flow at Site 1 to the south and east, and the flow at Site 3 to the northeast. Potentiometric surface maps were also generated for the deeper confined aquifers at Site 1 and the deeper portions of the aquifer at Site 3. These potentiometric surface maps are presented on Figures 3-10 and 3-11 which show the horizontal groundwater flow is to the east (towards the York River) at Site 1 and toward the northeast at Site 3.

In addition to the horizontal groundwater flow, the vertical flow potential was evaluated and is presented on the cross-section Figures 3-4 through 3-7. As presented on Figure 3-4, the groundwater flow in the Columbia aquifer trends downward toward the Cornwallis Cave confining unit. Summation of the horizontal and vertical groundwater flow components suggest that groundwater flows to the surficial soil on the side of the ravine and migrates to the intermittent creek that discharges toward Indian Field Creek.

Figures 3-4 through 3-7 present the vertical flow potential of the Cornwallis Cave/Yorktown-Eastover aquifer. The upper portions of the aquifer appear to be discharging locally into Indian Field Creek. Figures 3-4 and 3-6 show an upward flow potential toward the creek. At depth, the vertical flow potential changes direction. This is an indication of a separate, regional groundwater flow regime, with discharge to the York River.

In-situ hydraulic conductivity ("slug") tests were performed on February 14, 1996 in monitoring wells 1GW18, 1GW19, 1GW12A and 3GW19A. These monitoring wells were selected to collect conductivity data from the newly installed wells. These data were combined with the hydraulic conductivity data from the Round One RI to get an average hydraulic conductivity for the water

bearing units at the sites. The static water levels for monitoring wells 1GW18 and 1GW19 were below the top of the screen. Therefore, only rising head test data were used to estimate the specific hydraulic conductivities for these shallow (Type II) monitoring well (Bower, 1989). Falling and rising head tests were conducted in two deep (Type III) monitoring wells where the static water level encompassed the entire screen section. Specific testing procedures are outlined in Section 4.4.9 of the Master FSP for Naval Weapons Station Yorktown (Baker, 1994).

The field data were evaluated using the Geraghty and Miller aquifer test solver (AQTESOLV) program. The shallow (Type II) monitoring well data were evaluated using the Bouwer and Rice (1976) method for unconfined aquifers. The hydraulic conductivities obtained during the Round Two investigation were similar to the Round One conductivity data, therefore, the previous Round One conductivity data was used to determine the average hydraulic conductivity for the shallow water-bearing zone at Site 1. The average hydraulic conductivity for the Columbia aquifer at Site 1 is 4.17 feet per day (ft/day) or 1.47×10^{-3} cm/sec. The results of the hydraulic conductivity tests are summarized on Table 3-1. These values are within the range of hydraulic conductivities for silty sand deposits (Fetter, 1988).

The average hydraulic conductivity (determined by R.F. Weston during the Round One RI) for the shallow portion of the Cornwallis Cave/Yorktown-Eastover aquifer at Site 3 is 4.7×10^{-1} ft/day or 1.66×10^{-4} cm/sec. The results of the hydraulic conductivity tests are summarized on Table 3-1. These values are within the range of hydraulic conductivities for silty sand deposits (Fetter, 1988).

The deep (Type III) monitoring well data were evaluated using the Bouwer and Rice (1976) and Cooper et al methods for a confined aquifer. The average hydraulic conductivity for the Cornwallis Cave/Yorktown-Eastover aquifer at the site is 4.21×10^{-1} ft/day or 1.49×10^{-4} cm/sec. The results of the hydraulic conductivity tests are summarized on Table 3-1. These values are within the range of hydraulic conductivities for silty sand and sandy silt deposits (Fetter, 1988). A copy of the field data and AQTESOLV results are provided in Appendix 3B.

The groundwater gradients for both the Columbia (shallow) and the Cornwallis Cave/Yorktown-Eastover aquifer (deeper portion) were calculated from the February 14, 1996 groundwater level data. The average groundwater gradient for the Columbia aquifer (Site 1) was calculated at 8.3×10^{-2} feet/feet. The groundwater gradient for shallow portion the Cornwallis

Cave/Yorktown-Eastover aquifer (Site 3) calculated by Weston during the Round One RI is 2.0 x 10^{-2} feet/feet. The groundwater gradient for the deep portion of the Cornwallis Cave/Yorktown Eastover aquifer at Site 1 is 9.9 x 10^{-3} ft/ft. A gradient of 1.6 x 10^{-2} ft/ft was calculated for the deep portion of the Cornwallis Cave/Yorktown-Eastover aquifer at Site 3.

Using the average groundwater gradient and average hydraulic conductivity determined for each water-bearing zone (Cornwallis Cave and Yorktown-Eastover Aquifers), the average groundwater flow velocity can be estimated using a variation of Darcy's equation:

$$V = Ki/N_e$$

where: V = estimated groundwater flow velocity
K = hydraulic conductivity
i = hydraulic gradient
N_e = average effective porosity, as a decimal fraction

The hydraulic conductivity of the Columbia Aquifer was determined using an average K of 4.17 ft/day calculated from the hydraulic conductivity tests, a groundwater gradient of 8.3 x 10^{-3} feet/feet and an estimated effective porosity for silty sand of 0.30 (Fetter, 1988). The average groundwater flow velocity is 1.15 ft/day.

The average groundwater flow velocity of the shallow portion of Cornwallis Cave/Yorktown-Eastover Aquifer (Site 3) is 4.7 x 10^{-1} ft/day. This was determined using an average K of 8.3 ft/day, a groundwater gradient of 2.0 x 10^{-2} feet/feet, and an estimated effective porosity for silty sand of 0.35 (Fetter, 1988).

The average groundwater flow velocity of the deeper portion of Cornwallis Cave/Yorktown-Eastover Aquifer at Site 1 is 1.2 x 10^{-2} ft/day. This was determined using an average K of 4.21 x 10^{-1} ft/day, a groundwater gradient of 9.9 x 10^{-3} feet/feet, and an estimated effective porosity for silty sand of 0.35 (Fetter, 1988).

The average flow velocity of the deeper portion of the Cornwallis Cave/Yorktown-Eastover aquifer at Site 3 is 1.9 x 10^{-2} ft/day. This flow velocity was calculated using an average K of

4.21 x 10^{-1} ft/day, a groundwater gradient of 1.6 x 10^{-2} ft/ft, and an estimated effective porosity for silty sand of 0.35 (Fetter, 1988).

3.4 Land Use and Demography

Sites 1 and 3 are within the restricted area and are secured with locked gates. In addition, the sites are located inside an area encumbered by the Explosive Safety Quantity Distance (ESQD) and cannot be developed for real estate purposes. Currently there are no activities at either sites although WPNSTA personnel may hunt on the property during deer hunting season. Site 1 is mostly an open field surrounded by wooded areas and Site 3 is entirely wooded.

3.5 References

Baker Environmental, Inc. 1995. Summary of Background Constituent Concentrations and Characterization of the Biotic Community from the York River Drainage Basin, Naval Weapons Station Yorktown, Yorktown, Virginia Final. March 1995.

Baker Environmental, Inc. 1994a. Final Master Project Plans, Naval Weapons Station Yorktown, Yorktown, Virginia. June 1994.

Bouwer, H. 1989. The Bouwer and Rice Slug Test - An Update. Journal of Association of Ground Water Scientists and Engineers. May-June 1989 issue, v. 27, no. 3, pp. 304-309.

Bouwer, H. and R.C. Rice. 1976. A Slug Test for Determining Hydraulic Conductivity of Unconfined Aquifers With Completely or partially Penetrating Wells. Water Resources Research, v. 12, pp. 423-428.

Brockman, A. R. and D. L. Richardson. 1992. Hydrogeologic Framework of the Shallow Aquifer System of Yorktown, Virginia. Prepared in cooperation with York County Department of Environmental Services. USGS Water Resources Investigation Report 92-4111.

Dames and Moore. 1986. Confirmation Study Step 1A (Verification), Round One, Naval Weapons Station, Yorktown, Virginia. June, 1986.

Fetter, C.W. 1988. Applied Hydrogeology. 2nd edition, Columbus, Ohio: Merrill Publishing.

Johnson, G. H. 1972. Geology of the Yorktown Poquoson West and East Quadrangles, Virginia. Virginia Division of Mineral Resources, Report of Investigations 30.

Mixon, R. B., C. R. Berquist, Jr., W. L. Newell, and F. G. Johnson. 1989a. Geologic Map and Generalized Cross Sections of the Coastal Plain and Adjacent Parts of the Peidmont, Virginia. Virginia Division of Mineral Resources, Miscellaneous Investigations Series, Map I-2033.

Mixon, R. B., D. S. Powars, L. W. Ward, and G. W. Andrews. 1989b. "Lithostratigraphy and Molluscan and Diatom Biostratigraphy of the Haynesville Cores, Northeastern Virginia Coastal Plain, Chapter A." Mixon, R. B., Ed. Geology and Paleontology of the Haynesville Cores, Richmond County, Northeastern Virginia Coastal Plain. U.S. Geological Survey Professional Paper 1489.

Teifke, R. H. 1973. Stratigraphic Units of the Lower Cretaceous Through Miocene Series, in Geologic Studies, Coastal Plain of Virginia. Virginia Division of Mineral Resources, Bulletin 83, Parts 1 and 2.

TABLES

TABLE 3-1

SUMMARY OF WATER LEVEL MEASUREMENTS
SITES 1 AND 3
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Monitoring Well	Hydraulic Conductivity (ft/day)	Lithology of Screened Interval
1GW04[1]	5.5	Medium to fine SAND to clayey SAND
1GW05[1]	0.51	Sandy SILT to clayey SILT
1GW12[1]	2.1	Silty SAND
1GW12A[3]	9.60×10^{-2}	Sandy SILT, little shell fragments
1GW13[1]	1.1	Silty SAND
1GW14[1]	1.7	Medium to fine SAND, some silt
1GW17[1]	8.8	Coarse to fine SAND to silty SAND
1GW18[2]	8.35	Medium to fine SAND, little silt
1GW19[2]	5.33	Medium to fine SAND, little silt
3GW06[1]	5.5	Coarse to fine SAND
3GW07[1]	1.7	Silty SAND
3GW08[1]	10	Silty SAND
3GW18[1]	16	Shelly SAND
3GW19A[3]	7.46×10^{-1}	Silty SAND, trace shell fragments

Notes:

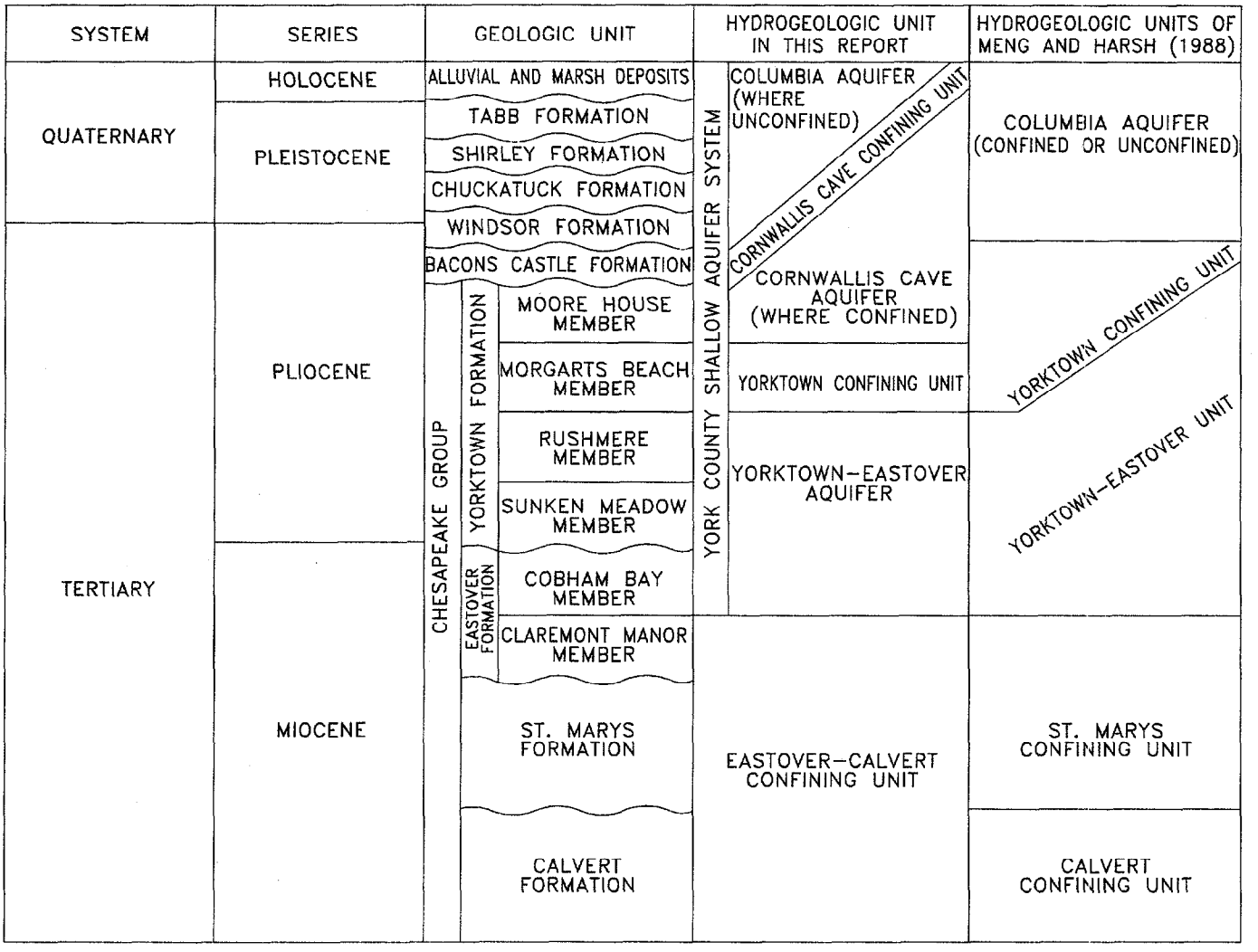
Hydraulic conductivity average for the Columbia aquifer at Site 1
4.17 ft/day

Hydraulic conductivity average for the shallow portion of the Cornwallis Cave/Yorktown-Eastover aquifer at Site 3:
4.7×10^{-1} ft/day

Hydraulic conductivity average for the deep portion of the Cornwallis Cave/Yorktown-Eastover aquifer at Sites 1 and 3
4.21×10^{-1} ft/day

(1) Hydraulic conductivity determined by R.F. Weston during the Round One RI
(2) Type II monitoring wells screened within the Columbia aquifer
(3) Type III monitoring wells screened within the Yorktown-Eastover aquifer

FIGURES

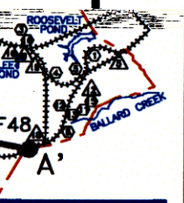


SOURCE: BROCKMAN, A.R. AND RICHARDSON, D.L. 1992
HYDROGEOLOGIC FRAMEWORK OF THE SHALLOW AQUIFER SYSTEM OF YORK COUNTY, VIRGINIA:
U.S. GEOLOGICAL SURVEY WATER–RESOURCES INVESTIGATIONS REPORT 92–4111.

Baker
Baker Environmental, Inc.

FIGURE 3-1
HYDROGEOLOGIC UNITS IN YORK COUNTY

NAVAL WEAPONS STATION YORKTOWN **YORKTOWN, VIRGINIA**



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Baker Environmental, Inc.

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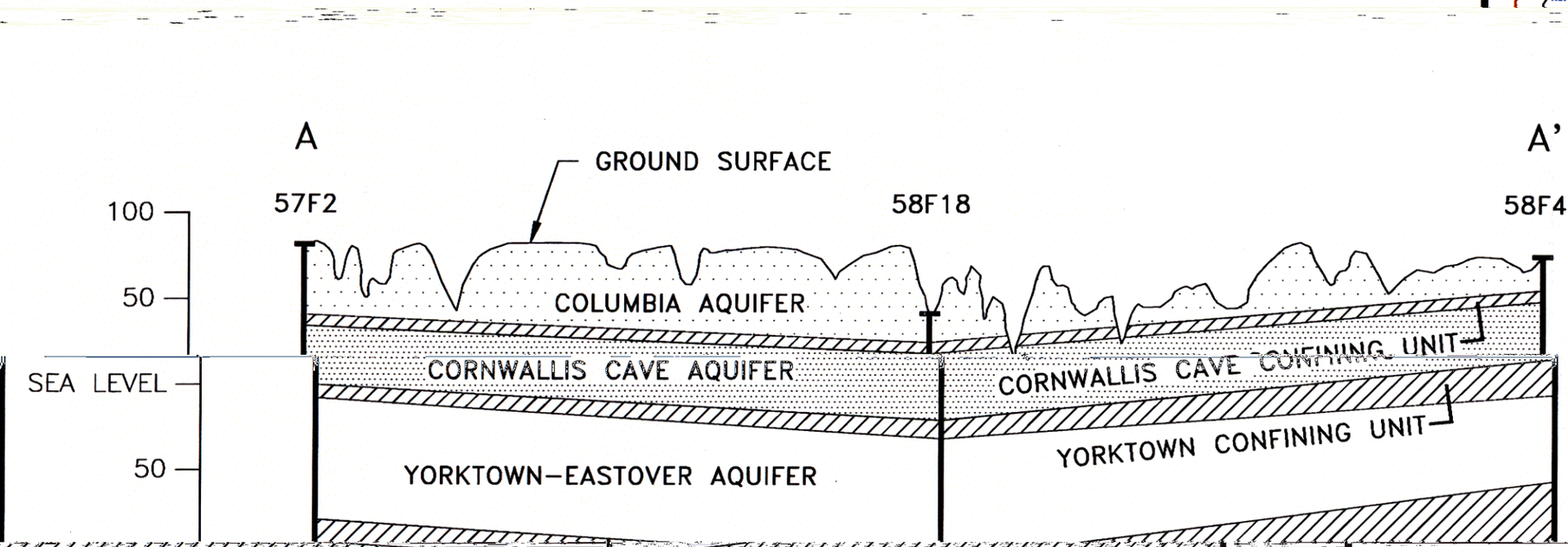
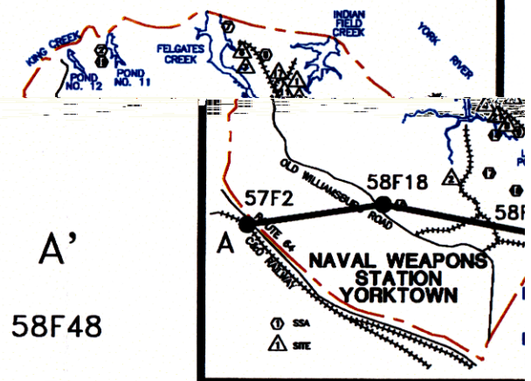




LEGEND

DESCRIPTION OF CROSS SECTION UN

COASTAL PLAIN DEPOSITS

COLUMBIA AQUIFER – UNCONFINED AQUIFER OF SANDY SE PLIOCENE BACONS CASTLE FORMATIC SEDIMENTS OF WINDSOR, CHUCKATU TABB FORMATIONS.

CORNWALLIS CAVE AQUIFER – CONFINED AND UNCONFINED AQUIFE SEDIMENTS OF THE UPPER PLIOCENE AND BACONS CASTLE FORMATION AN SEDIMENTS OF THE WINDSOR, CHUC TABB FORMATIONS.

YORKTOWN–EASTOVER AQUIFER – CONFINED AQUIFER IN SANDY AND SHELLY SEDIMENTS OF THE UPPER MIOCENE EASTOVER FORMATION AND THE LOWER PLIOCENE SEDIMENTS OF THE YORKTOWN FORMATION.

SEMI CONFINING UNITS COMPRISED OF SILTS AND CLAYS CORRESPONDING TO THE CORNWALLIS CAVE, YORKTOWN AND EASTOVER–CALVERT CONFINING UNITS.

57F2 BORING OR WELL LOCATION.

REFERENCES CITED:

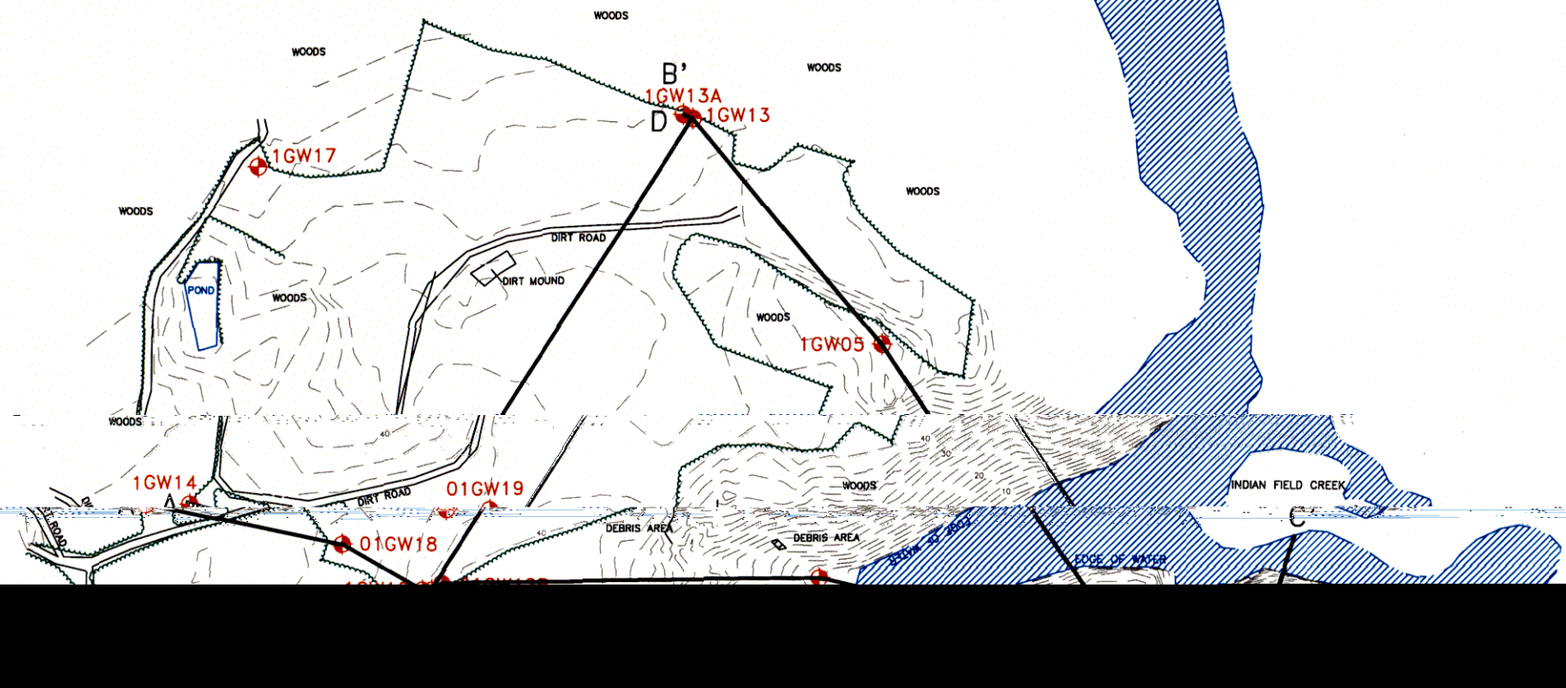
BROCKMAN, A.R. AND D.L. RICHARDSON, 1992. "HYDROGEOLOGIC FRAMEWORK OF THE SHALLOW AQUIFER SYSTEM OF YORK COUNTY, VIRGINIA".

320526WP

FIGURE 3-2
GENERALIZED HYDROGEOLOGIC CROSS SECTION
WPNSTA YORKTOWN, VIRGINIA

NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA

318705WP


WOODS
WOODS
WOODS
WOODS
WOODS
WOODS
WOODS
WOODS
B'
1GW13A
D
1GW13
1GW17
1GW05
DIRT ROAD
DIRT MOUND
POND
1GW14
A
01GW19
01GW18
DIRT ROAD
DEBRIS AREA
DEBRIS AREA
INDIAN FIELD CREEK
EDGE OF WATER
C
40
30
20
10

A
NORTHEAST

A'
SOUTHWEST

1GW14
01GW18
1GW12
01GW12A
01GW12B
3GW19A
3GW19
3GW07
1GW04

COLUMBIA AQUIFER

SM

yellow brown to fine little silt, medium SAND, wet

GROUND SURFACE

B.T. 30.2
B.T. 28.9
B.T. 28.1

ML
GRAINSIZE SAMPLE 1SB12A (15'-19')

CORNWALLIS CAVE CONFINING UNIT

silty SAND

gray SILT and clay trace fine sand, damp

INDIAN FIELD CREEK

brown, medium SAND little to fine silt, moist

brown and gray silt, trace fine CLAY and sand, dry

brown SILT and trace fine sand, clay damp

light gray SILT, some clay, fragments, wet

B.T. 2.7

brown to medium to fine SAND, little silt, wet

brown SILT, little sand, little shell fragments, trace clay, wet

B.T. -7.9
B.T. -6.7

gray medium to fine SAND little to some silt, little shell fragments, wet

B.T. -10.2

gray brown SILT, trace clay, dense to very some fine sand fragments, dense, wet

CORNWALLIS CAVE/YORKTOWN EASTOVER AQUIFER

SM
dark gray SILT, some fine sand trace clay damp

B.T. -23.6

gray fine little silt, shell dense SAND, trace fragments, medium to dense, wet

B.T. -46.7

ELEVATION (FEET, MSL)

40
30
20
10
0
-10
-20

318706WP

FIGURE 3-4
HYDROGEOLOGIC CROSS-SECTION A-A'
NAVL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LEGEND

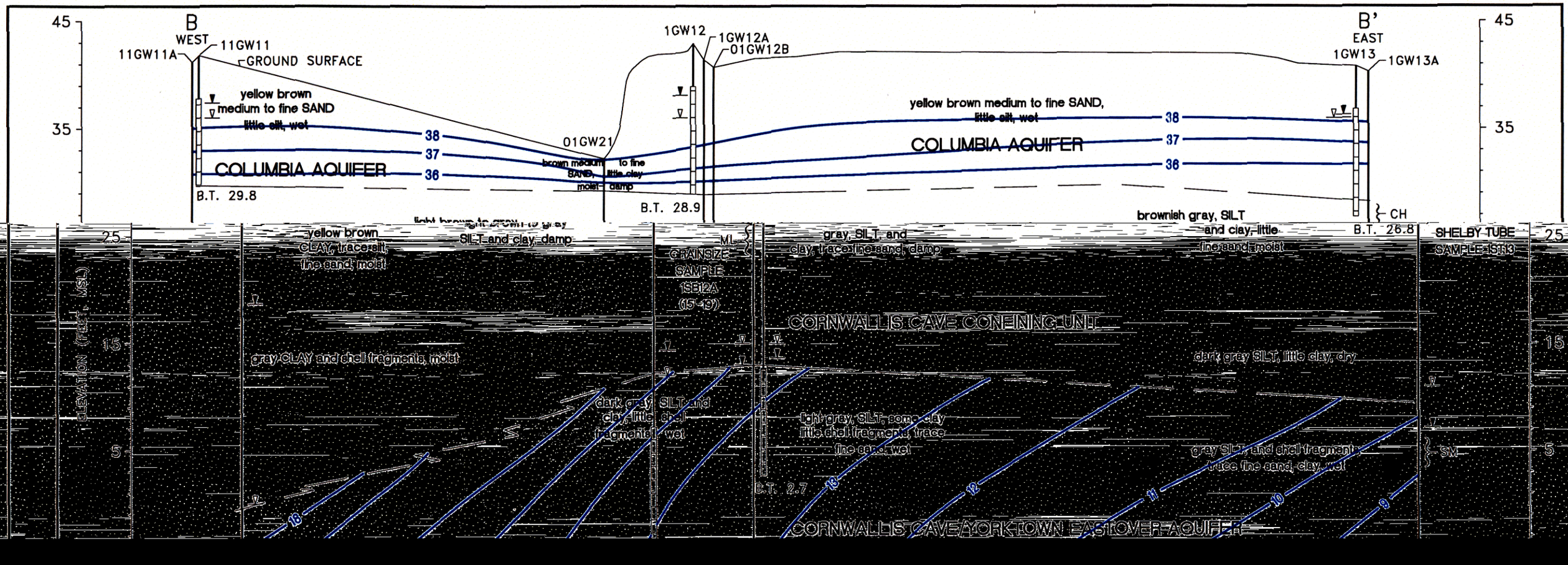
- GROUNDWATER ELEVATION
- GROUNDWATER ENCOUNTERED DURING DRILLING
- B.T. -23.6' BORING TERMINATED, ELEVATION MSL
- WELL SCREEN INTERVAL
- SM SILTY SAND - UNIFIED SOIL CLASSIFICATION SYSTEM (USCS)
- ML SANDY SILT - USCS
- ESTIMATED ----- PROJECTED
- ESTIMATED GROUNDWATER FLOW CONTOURS
- ZONE OF GREATER SOIL DENSITY

150 0 75 150 300
Horizontal Scale: 1 inch = 150 ft.

10 0 5 10 20
Vertical Scale: 1 inch = 10 ft.

THE SOIL BORING INFORMATION IS CONSIDERED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT THE RESPECTIVE BORING LOCATIONS. SUBSURFACE CONDITIONS INTERPOLATED BETWEEN BORINGS ARE ESTIMATED BASED ON ACCEPTED SOIL ENGINEERING PRINCIPLES AND GEOLOGIC JUDGEMENT.

Baker
Baker Environmental, Inc.


B
WEST
11GW11A
11GW11
GROUND SURFACE
yellow brown medium to fine SAND little silt, wet
COLUMBIA AQUIFER
B.T. 29.8
01GW21
brown medium SAND, moist
to fine little clay damp
1GW12
1GW12A
01GW12B
B.T. 28.9
B'
EAST
1GW13
1GW13A
yellow brown medium to fine SAND, little silt, wet
COLUMBIA AQUIFER
brownish gray, SILT and clay, little fine sand, moist
B.T. 26.8
CH
45
35
38
37
36
yellow brown CLAY, trace silt fine sand, moist
light brown to gray SILT and clay, damp
gray CLAY and shell fragments, moist
dark gray clay, little shell fragments, wet
SILT and shell fragments, wet
ML
GRAINSIZE SAMPLE 1SB12A (15'-19')
gray SILT and clay, trace fine sand, damp
CORNWALLIS CAVE CONFINING UNIT
dark gray SILT, little clay, dry
light gray, SILT, some clay little shell fragments, trace fine sand, wet
gray SILT and shell fragments, trace fine sand, clay, wet
B.T. 2.7
CORNWALLIS CAVE/YORKTOWN EASTOVER AQUIFER
SHELBY TUBE SAMPLE 1ST13
SM
25
15
5
18
12
11
10
9
ELEVATION (FEET, MSL)

318708WP

C
SOUTHWEST

C'
NORTHEAST

FORMER BORROW PIT AND
GROUP 18 MAGAZINE LANDFILL

ELEVATION (FEET, MSL)

50
40
30
20
10
0
-10

3GW06
3GW19A
3GW19
3GW15
3GW15A

GROUND SURFACE

yellow brown SAND, some silt, moist

yellow brown to light gray CLAY, light silt, moist

light brown fine SAND, coarse to trace silt, damp

light brown CLAY, little silt, trace fine sand, damp

olive-gray yellow CLAY and shell fragments, trace silt, sand, moist

light brown silt, SAND and trace clay

gray CLAY, trace fine sand, damp

brown CLAY and gray and silt, damp

yellow brown, SILT and shell fragments, wet

fine SAND and shell fragments, little silt, wet

brown SILT little shell and fine sand, fragments, wet

INDIAN FIELD CREEK

10
9
8
7
6
5
4
3
2
1

CORNWALLIS CAVE/YORKTOWN EASTOVER AQUIFER

B.T. -4.8

B.T. -7.5

B.T. -7.9

dark gray and silt, trace

fine SAND shell fragments, wet

light brown SAND, little

medium to fine shell fragments, silt, wet

dark gray sand, very stiff

SILT and fine trace shells, to hard, wet

dark gray little shells

fine SAND silt, trace dense, wet

B.T. -40.3

B.T. -46.7

LEGEND

- GROUNDWATER ELEVATION
- GROUNDWATER ENCOUNTERED DURING DRILLING
- B.T. -4.8' BORING TERMINATED, ELEVATION MSL
- WELL SCREEN INTERVAL
- ESTIMATED ——— PROJECTED
- ZONE OF GREATER SOIL DENSITY
- 10 ESTIMATED GROUNDWATER FLOW CONTOURS

60 0 30 60 120
Horizontal Scale: 1 inch = 60 ft.

10 0 5 10 20
Vertical Scale: 1 inch = 10 ft.

THE SOIL BORING INFORMATION IS CONSIDERED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT THE RESPECTIVE BORING LOCATIONS. SUBSURFACE CONDITIONS INTERPOLATED BETWEEN BORINGS ARE ESTIMATED BASED ON ACCEPTED SOIL ENGINEERING PRINCIPLES AND GEOLOGIC JUDGEMENT.

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FIGURE 3-6
HYDROGEOLOGIC CROSS-SECTION C-C'

NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

1ED.

D WEST

D' EAST

318709WP

FORMER SAND PIT

FORMER BORROW PIT AND GROUP 16 MAGAZINES LANDFILL

GROUND SURFACE

1GW13

1GW13A

1GW05

3GW06

3GW15

3GW15A

coarse to fine SAND, some silt, wet

COLUMBIA AQUIFER

gray to medium to fine SAND and silt, wet

brown, SAND and silt, dry

light brown coarse to fine SAND, trace silt, damp

CH

B.T. 26.8

brown to gray SILT and clay, little fine sand, moist

green gray SILT and fine sand, moist

light brown CLAY, little silt, trace fine sand

green gray SILT and clay, damp

B.T. 18.8

gray CLAY, trace silt, finw sand, damp

silty SAND

light brown, SAND and silt, trace clay

dark gray SILT, little clay, dry

CORNWALLIS CAVE CONFINING UNIT

gray clay, trace fine sand

INDIAN FIELD CREEK

yellow brown, SILT and shell fragments, wet

gray brown, SILT and shell fragments trace fine sand, clay, wet

SM

brown SILT and little shell

fine sand fragments, wet

gray SILT and fine to medium sand, trace shell fragments, wet

CORNWALLIS CAVE/YORKTOWN EASTOVER AQUIFER

B.T. −7.5

B.T. −6.9

gray fine SAND and silt, trace shell fragments, dense to very dense, wet

gray SILT and fine sand, trace shell fragments, wet

B.T. −34.7

B.T. −40.3

ELEVATION (FEET, MSL)

45 35 25 15 5 −5 −15

LEGEND

- GROUNDWATER ELEVATION
- GROUNDWATER ENCOUNTERED DURING DRILLING
- B.T. −34.7' BORING TERMINATED, ELEVATION MSL
- WELL SCREEN INTERVAL
- ESTIMATED ——— PROJECTED
- CH INORGANIC CLAY (USCS)
- SM SILTY SAND (USCS)
- ZONE OF GREATER SOIL DENSITY
- ESTIMATED GROUNDWATER FLOW CONTOURS

Horizontal Scale: 1 inch = 100 ft. (100 0 50 100 200)

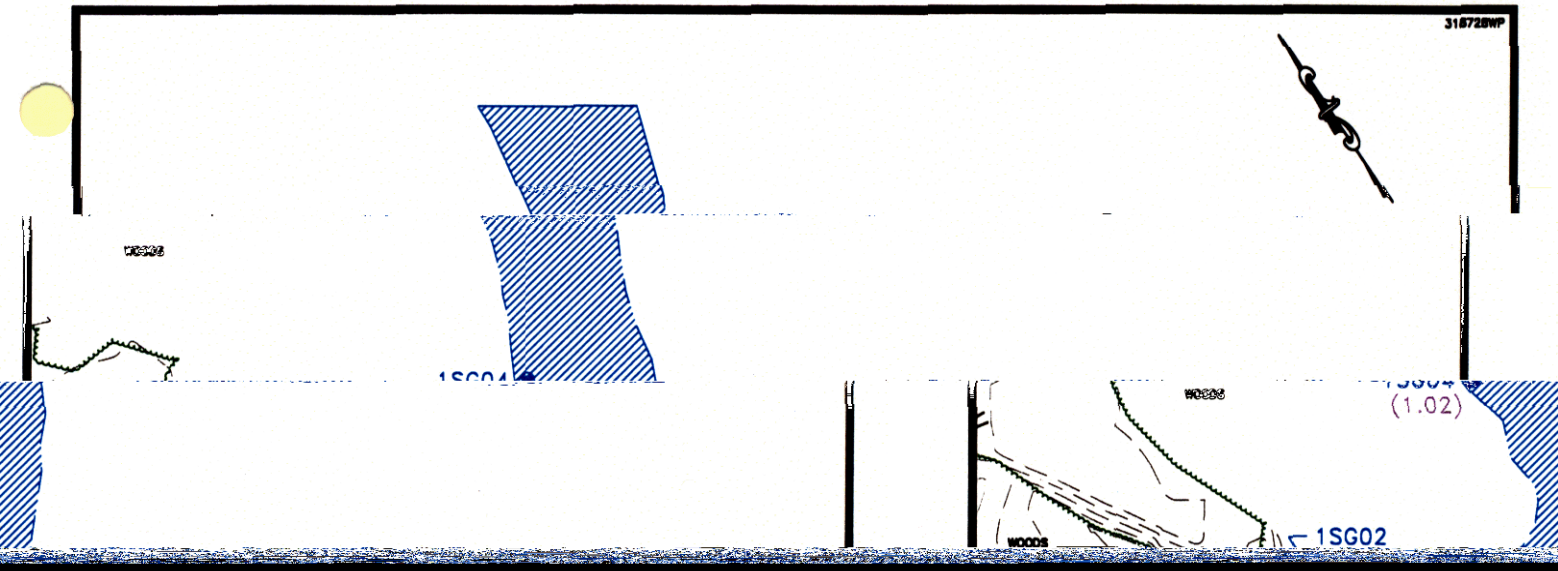
Vertical Scale: 1 inch = 10 ft. (10 0 5 10 20)

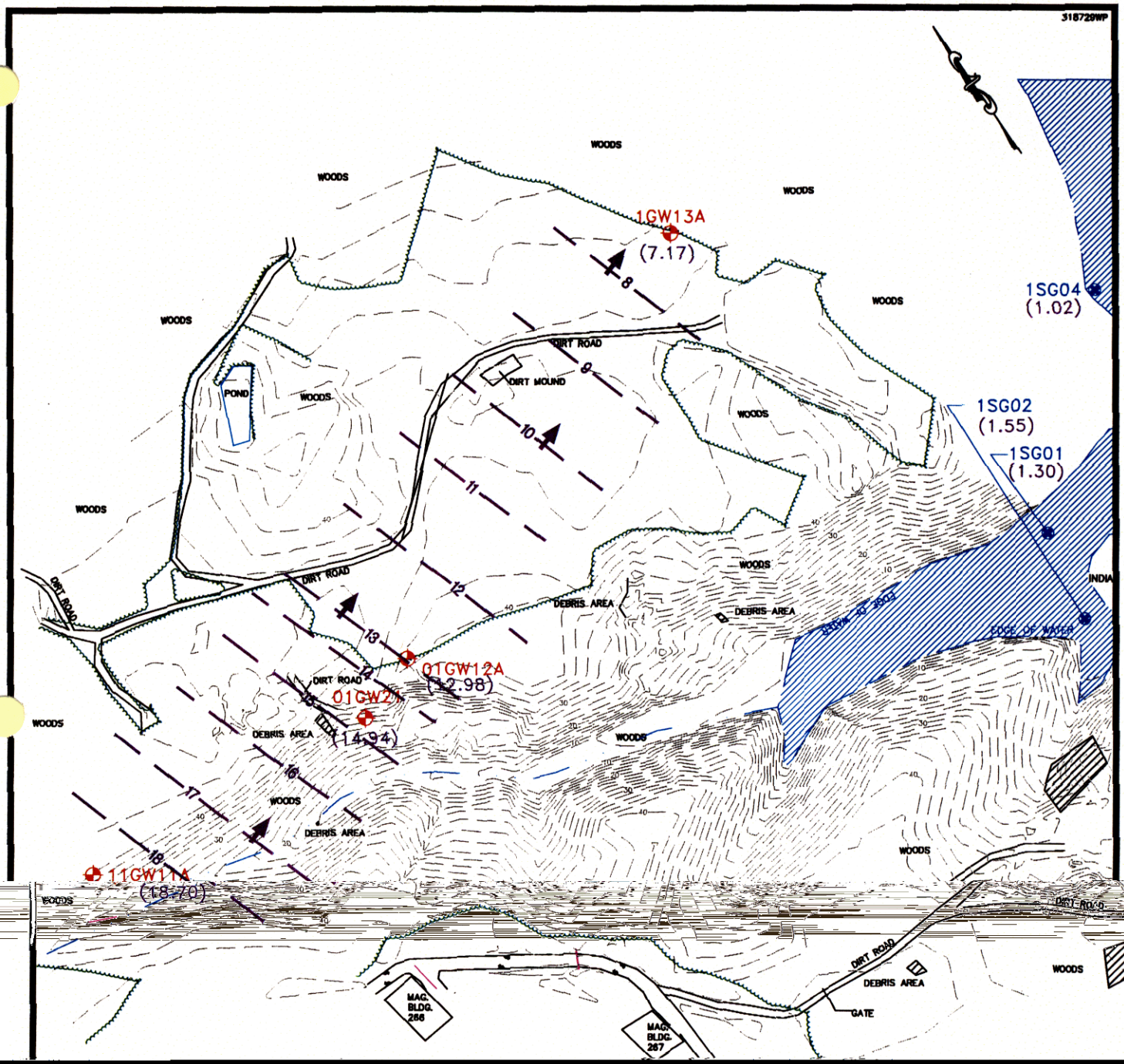
THE SOIL BORING INFORMATION IS CONSIDERED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT THE RESPECTIVE BORING LOCATIONS. SUBSURFACE CONDITIONS INTERPOLATED BETWEEN BORINGS ARE ESTIMATED BASED ON ACCEPTED SOIL ENGINEERING PRINCIPLES AND GEOLOGIC JUDGEMENT.

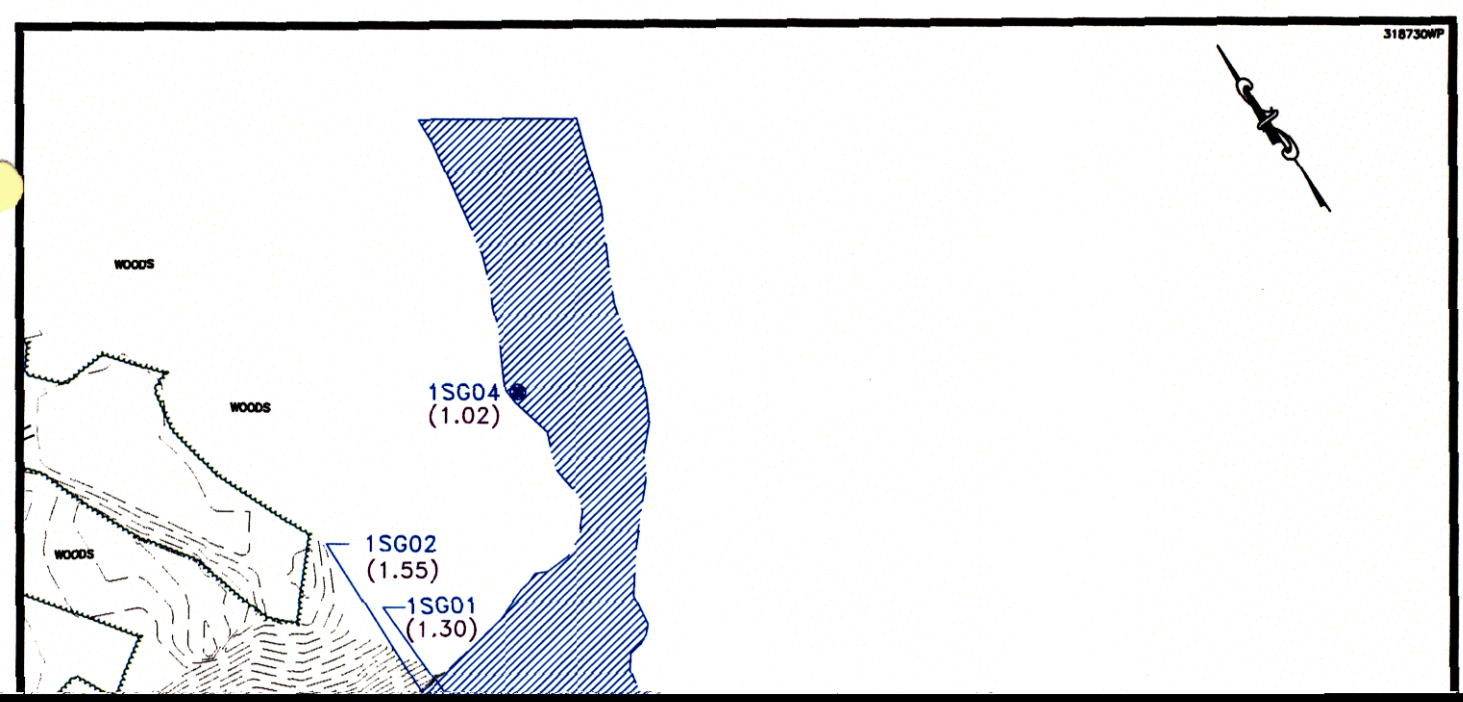
FIGURE 3-7
HYDROGEOLOGIC CROSS-SECTION D

NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

aker
er Environmental, Inc.
-D'


316728WP
WD08
1SG02
(1.02)


318729WP
WOODS
1GW13A
(7.17)
1SG04
(1.02)
1SG02
(1.55)
1SG01
(1.30)
POND
DIRT MOUND
DIRT ROAD
DEBRIS AREA
01GW12A
(12.98)
01GW2
(14.94)
11GW11A
(18.70)
INDIA
EDGE OF WATER
MAG. BLDG. 266
MAG. BLDG. 267
GATE


318730WP
WOODS
WOODS
WOODS
1SG04
(1.02)
1SG02
(1.55)
1SG01
(1.30)

4.0 NATURE AND EXTENT OF CONTAMINATION

This section presents chemical analytical results obtained as part of the Round Two RI performed at Sites 1 and 3 and discusses both Round One and Round Two sampling results. The objectives of this section are to characterize the nature and delineate the extent of possible site contamination. The characterization of Sites 1 and 3 is based upon collection and analysis of samples of the following environmental media: surface and subsurface soil, groundwater, surface water, sediment, and biota.

The analytical results are presented in two groups. Non-site related analytical results, presented in Section 4.1, include laboratory contaminants, essential nutrients, and other naturally occurring inorganic elements. Analytical results from the environmental investigation presented in Section 4.2, include results of the soil, groundwater, surface water, and sediment investigations (Section 7.0 presents the results of the biota sampling). Section 4.2 includes the environmental sample results (i.e., soil samples collected from within the study area) and related background sample results (i.e., site-specific background soil samples) to evaluate whether or not the detected constituents (particularly the inorganics) are site-related. Section 4.3 describes the extent to which contaminants have migrated from probable source areas and the potential for future migration using the Round One and Round Two sampling results.

Appendices 4.A through 4.D present the Round Two chain-of-custody forms, Round Two sampling summary, Round Two analytical laboratory results, and Round Two QA/QC results, respectively. Figures 4-1 through 4-10 provide a graphical depiction of organic and inorganic contaminants as they occur throughout the site. Positive detections of organic compounds and inorganic analytes according to media are presented in summary tables included at the end of this section (Tables 4-3 through 4-25).

4.1 Potential Non-Site-Related Analytical Results

Many of the organic compounds and inorganic constituents detected during investigations of the various environmental media could potentially be attributed to non-site-related conditions. Two potential sources of this include sampling/laboratory (blank) contaminants and the presence of naturally occurring constituents (background).

4.1.1 Sampling/Laboratory Contaminants

Blank samples provide a measure of contamination that has been introduced into a sample set during its collection, transportation, preparation, and/or analysis. The concentrations of chemicals detected in blanks were compared with concentrations of the same chemicals detected in environmental samples.

Common laboratory contaminants (i.e., acetone, 2-butanone, methylene chloride, and phthalate esters) are considered by USEPA as positive results only when concentrations in the environmental sample exceed ten times the concentration detected in any blank. If the concentration of a common laboratory contaminant in an environmental sample was less than ten times the associated blank concentration, then it was concluded that the chemical was not detected in that particular sample (USEPA, 1989). Because of the complexity of associating laboratory or sampling induced contamination with concentrations detected in environmental samples, maximum detected concentrations of laboratory or sampling induced contaminants detected in blanks were used in the evaluation. The maximum concentrations of common laboratory contaminants detected in blanks during the investigation at Sites 1 and 3 are as follows:

- Acetone 21 µg/L
- Toluene 3J µg/L
- bis(2-Ethylhexyl)phthalate 460 µg/L
- Di-n-butylphthalate 22 µg/L

A "J" qualifier indicates that the reported sample concentration value has been estimated. A "B" qualifier indicates that the reported concentration is itself qualified as blank contamination because of an association with another type of blank (for example, a trip blank qualified because of contamination in a laboratory blank). A list of the qualifiers and their definitions is presented in Table 4-1.

Organic contaminants detected in laboratory blanks but not considered to be common laboratory contaminants also were evaluated. In general, all organic compounds at less than five times the maximum level of contamination noted in any blank may not be attributed specifically to the site

conditions. The maximum concentrations of all other detected blank contaminants (organics) are as follows:

- Chloroform 51µg/L
- 1,2-Dichloroethene 5J µg/L
- 2-Butanone 44 µg/L
- Bromodichloromethane 8J µg/L
- Trichloroethene 100 µg/L
- Tetrachloroethene 3J µg/L
- Phenol 18 µg/L
- 2-Methylphenol 4J µg/L
- Diethylphthalate 10 µg/L
- 1,2,4-Trichlorobenzene 2J µg/L
- 2,6-Dinitrotoluene 3J µg/L

Possible laboratory contaminants for each site are presented/discussed in Section 6.0 and listed in Table 6-1. The above-listed compounds are presented in the positive detection summary tables in this section; however, the majority of them are not included in the figures (Figures 4-1 through 4-10). The compounds, trichloroethene and 1,2-dichloroethene were qualified as blank contaminants within some groundwater samples (1GW12 and 1GW12A; however, they will be discussed in the following sections and are included on the figures because they were detected in previous investigations.

4.1.2 Naturally Occurring Inorganic Elements

Unlike organics, many of the inorganic parameters, for which environmental samples were analyzed, do occur naturally. For example, lead is an element that occurs naturally in most soil (in low concentrations) but also is considered a contaminant if its concentration is well above background levels and its presence can be attributable to site operations (e.g., lead from lead-based paints or batteries).

In order to differentiate between inorganic contamination from site operations and naturally-occurring inorganic elements, the results of the sample analyses (concentrations) were

compared to information regarding background conditions at WPNSTA Yorktown. This information was collected during a Station-wide investigation in 1994 and presented in the Summary of Background Constituent Concentrations and Characterization of the Biotic Community from the York River Drainage Basin (Baker, 1995). A summary of these data are provided in Table 4-2.

4.2 Round Two RI Analytical Results

The following subsections present analytical results for the environmental samples collected during the Round Two RI at Sites 1 and 3. Analytical results are presented for the :

- Surface and subsurface soil investigation
- Groundwater investigation
- Surface water investigation
- Sediment investigation

Tables 4-3 through 4-25 present all the organic and inorganic contaminants detected in the samples. In order to limit the number of compounds depicted on the figures and to better show hot spots only the chemicals of potential concern (COPCs) are shown on Figures 4-1 through 4-10.

Laboratory contaminants and naturally occurring constituents detected in the various samples are not evaluated in this section. Inorganic constituents considered to be essential human nutrients will not be addressed in this section. Essential nutrients include calcium, magnesium, potassium, and sodium (USEPA, 1989). Results of the biota investigation are presented in Section 7.0 (Ecological Risk Assessment).

4.2.1 Site 1 Analytical Results

The following sections present analytical results for the environmental samples collected during the Round Two RI at Site 1 by media.

4.2.1.1 Soil Investigation

The analytical results from the surface and subsurface soil investigation are discussed below. At the end of these sections is a discussion of physical results of the test pitting activities.

Surface Soil Investigation Results

The results of the Round One RI were used to select sampling locations for the Round Two RI. In general, the results of the Round Two surface soil investigation at Site 1 were consistent with the Round One results.

Generally, low concentrations of SVOCs, mainly polynuclear aromatic hydrocarbons (PAHs) were detected within twelve of the twenty-one surface soil samples (including duplicates)collected at Site 1.

Low concentrations of the pesticide compounds dieldrin, 4,4-DDT, alpha-chlordane, and gamma-chlordane were detected at within one sample (1GW19-00) and low levels of aroclor-1260 was detected in 1GW18-00. Nitramine compounds were not detected in any surface soil samples. Figure 4-1 presents the organic COPCs detected at the site.

Fifteen of 20 inorganics were detected in surface soil samples. Mercury, silver, thallium, and cyanide were not detected in the sample set.

Two inorganic compounds (arsenic and lead) were detected at levels exceeding Station-wide background concentrations. Arsenic was detected in the sample 1SB12A-00 at a concentration of 92.5 mg/kg and lead was detected at a concentration of 62.3 mg/kg in the sample 1SB19-00 (Table 4-4). As depicted on Figure 4-2, the most prevalent COPCs detected within the sample set are arsenic, beryllium, and iron. Detections of aluminum were less frequent.

Positive detections of organic compounds and inorganic analytes are presented, by sampling location, on Figures 4-1 and 4-2. Tables 4-3 and 4-4 summarize analytical results for surface soils at Site 1.

Subsurface Soil Investigation Results

Subsurface soil samples collected at soil boring and test pit locations. These locations and the inorganic analytes and organic compounds detected at each location are presented in Figures 4-3 and 4-4. Tables 4-5 to 4-7 summarize results including engineering parameters for subsurface soils at Site 1.

No VOCs were detected in the subsurface soils. Low concentrations of SVOCs were detected at two locations (1GW12 and 1GW18) within the western portion of the site.

Six pesticide compounds were detected within one sample (1GW19-01;1-to 3-ft bgs) at relatively low concentrations. Similar compounds and concentrations were detected in the surficial soil sample collected at this location. In addition, one PCB compound (aroclor-1260) was detected at low concentrations at the same location but at a greater depth (3- to 5-ft bgs). This same PCB compound was detected at low concentrations at 1GW20 (1- to 3-ft bgs).

Nitramines were not detected in the subsurface soil samples.

Sixteen of 20 inorganics were detected within the subsurface soil samples, mercury, silver, thallium and cyanides were not detected in the sample set.

The inorganic analytes above Station-wide background levels were identified at two locations. Cadmium was detected at low levels (background concentrations were nondetect) at two locations 1SB12A and 1SB19. Additional inorganics detected above background concentrations include arsenic at 1SB12 (126 mg/kg; 1- to 3-ft bgs) and lead at 1SB19 (57.4 mg/kg; 1- to 3-ft bgs). The most prevalent COPCs detected were arsenic, beryllium, and iron. Detections of aluminum, antimony, and manganese were less frequent.

This section presents the physical descriptions and observations determined from test pit excavations. The analytical results of the soil samples collected within the test pits are presented on Tables 4-5 to 4-7. Four test pits were excavated within the suspected landfill area as shown on Figure 2-2. The test pits were excavated to depths of 4.5- to 8-feet bgs when the natural soil horizon was determined. Test pit 1TP01 was excavated north of the dirt access road. The soil in this area

was determined to be natural therefore, the landfill does not extend north of the road at this location. Through the excavation of remaining test pits it was determined that there was approximately 6- to 7-feet of fill material covering the landfill. The fill material consisted of sandy soil with a mixture of debris (concrete, scrap metal, styrofoam, wood, rail road ties, and tree limbs) In addition, a 6- to 8-inch layer of white lenses grinding dust was encountered at approximately 3-feet bgs within 1TP04. Details of the test pit findings are presented on Table 4-26 and test pit logs are presented in Appendix 2A.

4.2.1.2 Groundwater Investigation Results

The following subsections discuss the results of samples collected from the shallow groundwater zone (Columbia aquifer) and the deeper groundwater zone (Cornwallis Cave/Yorktown-Eastover aquifer).

Shallow groundwater

VOCs, SVOCs, and nitramines were detected in seven of the eleven shallow groundwater samples collected at Site 1 (see Figures 4-5 and 4-6 and Tables 4-8 to 4-10).

Three of the monitoring wells (1GW12, 1GW19, and 1GW20) had concentrations of 1,2-dichloroethene and trichloroethene. The highest concentration of trichloroethene (190 µg/L) detected in 1GW20 exceeded the Federal maximum contaminant levels (MCLs) and the Virginia MCLs. This monitoring well was located in an area adjacent to where metal drums were found at the surface during a site visit in March, 1995. The concentrations of trichloroethene (64 µg/L) and 1,2-dichloroethene (40 µg/L) detected at 1GW12 were attributed to blank contamination by the validator. Refer to the end of Appendix 4D for the validation report regarding this sample. Previous sampling of this monitoring well during the Round One RI indicated elevated concentrations of TCE (18,000 µg/L) and 1,2-DCE (1,000 J µg/L). In July, 1995 the monitoring well was sampled to confirm the Round One results and concentrations of TCE (3,900 µg/L) and cis-1,2-DCE (520 µg/L) were detected. Although qualified as blank contaminants, TCE and 1,2-DCE are presented on Figure 4-5 because of past detections and the frequency of defect within this sampling round. Further discussion of the Round I and II groundwater sample results is presented in the extent of groundwater contamination (Section 4.3.1.2).

Low concentrations of pentachlorophenol and nitrobenzene were detected in four of the samples collected.

Relatively low concentrations of total inorganics were detected in the shallow groundwater samples. Thirteen of 20 inorganics were detected within the sample set. Antimony, beryllium, mercury, nickel, silver, thallium and cyanide were not detected. Only four samples exceeded Station-wide background levels for at least one of the following analytes: cadmium, iron, manganese and zinc. Only cadmium exceeded the Federal MCLs at a concentration of 8.6 µg/L at 1GW12. Arsenic, iron, and manganese were the prevalent COPCs detected as shown on Figure 4-6.

Twelve of 20 dissolved inorganics were detected in the sample set. Antimony, beryllium, chromium, mercury, selenium, silver, thallium, and cyanide were not detected.

Concentrations of dissolved inorganics exceeded Station-wide background levels in at least one of the following analytes: aluminum, barium, cadmium, cobalt, copper, iron, lead, manganese, nickel, and zinc. Only cadmium exceeded the Federal MCLs at a concentration of 9.0 µg/L at 1GW12. The most prevalent COPCs presented on Figure 4-6 are arsenic, cadmium, iron and manganese.

Deep groundwater

VOCs, and SVOCs were detected in three of the six deep groundwater samples (including duplicates) collected at Site 1 (see Figures 4-7 and 4-8 and Tables 4-11 to 4-13).

Three of the monitoring wells (1GW12A, 1GW12B, and 1GW21) had concentrations of trichloroethene. The highest concentration of trichloroethene (360 µg/L) detected in 1GW12B exceeded both the Federal MCLs and the Virginia MCLs. This well was located near an area where TCE was detected in the shallow groundwater (1GW20 at 190 µg/L). The concentrations of trichloroethene (46 µg/L) detected at 1GW12A were attributed to blank contamination by the validator. Low concentrations of SVOCs were detected in at three of the six deep monitoring wells.

Fifteen of 20 inorganics were detected above detection limits. Antimony, beryllium, thallium, and cyanide were not detected.

Relatively low concentrations of total inorganics were detected the deep groundwater samples. Only one sample (1GW13A-01 and the duplicate) exceeded Station-wide background levels for the following analytes: aluminum, barium, cadmium, chromium, copper, iron, lead, manganese, nickel, vanadium and zinc. Only chromium exceeded the Federal MCLs at a concentration of 154 µg/L at 1GW13A.

Low concentrations of eight dissolved inorganics were detected the deep groundwater samples. Only two samples (11GW11AF-01 and 1GW21F-01) exceeded Station-wide background levels for lead at concentrations of 0.86 µg/L and 2.4 µg/L, respectively. Federal or Commonwealth of Virginia groundwater criteria was not exceeded by of the sample concentrations.

4.2.1.3 Surface Water, Sediment, and Biota Investigation

The following subsections present a discussion on the analytical results for surface water, sediment, and biota samples collected in Indian Field Creek.

Surface Water Investigation Results

Three surface water samples were collected from the Indian Field Creek sampling locations (See Figure 4-9 and Tables 4-17 to 4-19). Locations 1SW13 and 1SW14 were dry therefore samples could not be collected.

No VOCs, SVOCs, or pesticides/PCBs were detected in the samples.

Aluminum, barium, cadmium, copper, iron, lead, manganese, vanadium and zinc were detected at relatively low concentrations within the sample set. Only the concentrations of cadmium and copper exceeded Station-wide background levels.

Sediment Investigation Results

VOCs, SVOCs, or pesticides/PCBs were not detected in any of the sediment samples collected at five locations at Site 1 (see Figure 4-10 and Tables 4-16 through 4-18).

Thirteen of 20 inorganics were detected in the sediment samples. Antimony, beryllium, cobalt, mercury, silver, thallium and cyanide were not detected within the sample set.

Arsenic, cadmium and lead exceeded Station-wide background levels in three of the samples (1SD15-01, 1SD16-01D, and 1SD16-02). Arsenic was the most prevalent COPC detected.

Biota Investigation Results

The biota investigation for the Round Two investigation included benthic macroinvertebrate sampling and fish population sampling. These results are presented in Section 7.0 (Ecological Risk Assessment).

4.2.2 Site 3 Investigative Results

The following sections present analytical results for the environmental samples collected during the Round Two RI at Site 3 by media.

4.2.2.1 Soil Investigation

This section presents analytical results from the soil investigation (surface and subsurface soil) at Site 3. Also presented is a discussion on the physical results of test pitting activities. Surface soil results are depicted on Figures 4-1 and 4-2; subsurface soil results are depicted on Figures 4-3 and 4-4. Tables 4-19 and 4-20 summarize surface soil results for Site 3, Tables 4-21 to 4-22 summarize subsurface results, and Table 4-26 summarizes the test pitting results.

Surface Soil Investigation Results

Low concentrations of SVOCs, mainly PAHs were detected within one (3SB08A-00) of the sixteen surface soil samples collected at Site 3. A second sample 3SS10 had detections of similar PAHs but at elevated concentrations (see Figure 4-1). In addition, low concentrations of pesticides were detected in the same samples. Sample 3SS11 had low concentrations (31 µg/kg) of the PCB aroclor-1260. Nitramine compounds were not detected in any surface soil samples.

Nineteen of 20 inorganics were detected in the surface soil samples. Only silver was not detected within the sample set.

Inorganic concentrations exceeded Station-wide background levels in nine of the samples for at least one or more of the following analytes: antimony, barium, beryllium, chromium, iron, lead, manganese, mercury, nickel, selenium, thallium, vanadium, zinc, and cyanide. The most prevalent COPCs detected were arsenic, beryllium, and iron as shown on Figure 4-2.

Confirmation Surface Soil Results

On August 26, 1996, five confirmatory surface (0- to 6-inches) and one subsurface (18- to 24-inches) soil samples were collected around the 3SS10 sample location as presented on Figure 4-1A. The samples were analyzed for SVOC. Further inspection of the sample locations showed a "tar-like" substance within the surficial soil (0- to 6-inches). The analytical results showed similar PAH compounds but at greatly reduced concentrations except in Sample 3SS10C which had similar (but slightly reduced) concentrations as 3SS10.

Subsurface Soil Investigation Results

Subsurface soil samples were collected at soil boring and test pit locations. These locations and the inorganic and organic analytes detected at each location are presented in Figures 4-3 and 4-4. Tables 4-21 to 4-22 summarize results for subsurface soils at Site 3.

Two VOCs (1,2-dichloroethene and ethylbenzene) were detected in two samples (3TP02 and 3TP02D).

Relatively low concentrations of SVOCs were detected in three of the samples (3SB15-12, 3TP02, and 3TP02D). In addition, low concentrations of pesticides were detected in 3SB15A-12.

Nitramines were not detected in the subsurface soil samples

Nineteen of 20 inorganics were detected in the subsurface soil samples. Only silver was not detected within the sample set.

Relatively low concentrations of fifteen total inorganics were detected in the deep groundwater samples. Antimony, mercury, silver, thallium, and cyanide were not detected in the sample. Only one sample (3GW19-01) exceeded the Federal and the state of Virginia MCLs for chromium at a concentration of 177 µg/L and the Federal MCL for lead at a concentration of 22 µg/L. Arsenic and iron were the most prevalent COPCs detected as shown on Figure 4-8.

Aluminum, chromium, and manganese concentrations exceeded Station-wide background levels for dissolved inorganics in seven samples (3GW08F, 3GW08AF, 3GW15F, 3GW15AF, 3GW18F, 3GW18FD and 3GW19F). There were no exceedences of the Federal or state of Virginia MCLs for dissolved inorganics within the sample set.

4.3 Extent of Contamination

This section describes the extent to which contamination has migrated at Sites 1 and 3. Note that the discussion focuses on organic contamination. Inorganic constituents were detected in all the media sampled as part of the Round Two investigation. Based on a review/evaluation of the data, no trends or hot spots of inorganic contamination were identified. The detected inorganic concentrations will be evaluated in the human health and ecological risk assessments; however, the extent of inorganics in the various site media will not be presented in the following subsections.

4.3.1 Site 1

4.3.1.1 Surface and Subsurface Soil

The following subsections discuss the extent of contamination at Site 1.

Surface Soil

Following evaluation of data collected during the Round One RI, low concentrations SVOCs were identified as soil contaminants across Site 1. This is consistent with the analytical results of the Round Two sampling event. The low concentrations of SVOCs (mainly PAHs) are generally spread throughout the landfill and did not exhibit a pattern. The SVOCs detected are possibly related to past disposal practices.

Low concentrations of pesticides that were detected in one sample are consistent with historical use of Station-wide spraying. One PCB compound was detected at low concentrations at the surface soil sample collected at 1GW18 and may be attributable to past site operations.

Inorganic concentrations slightly exceeded Station-wide levels for arsenic and lead in one sample for each analyte.

Overland transport of contaminated soils by runoff flowing toward Indian Field Creek is a potential pathway for surface soil contaminant migration. Analytical results from surface water/sediment samples collected in Indian Field Creek indicates that the surface soil contaminants detected at Site 1 have not migrated to or had an impact on this surface water body.

The surface soil at Site 1 has not been significantly impacted by site operations. There is no apparent source or discernible pattern of contamination within this media.

Subsurface Soil

Results of the subsurface soil investigation at Site 1 were similar to the results of the surface soil investigation. Relatively low concentrations of SVOCs (mainly PAHs) were detected at two locations.

Low levels of pesticides were detected at one location (1GW19) at a depth of 1- to 3-feet bgs. Similar compounds and concentrations were detected within the surface soil sample collected at this location. These detections are consistent with historical use of Station-wide spraying. One PCB compound was detected at low concentrations at two locations 1GW19 and 1GW20 at depths of 1- to 3-feet bgs. These concentrations were detected within the surface soil (1GW18) and may be attributable to past site operations.

Inorganics detected within the subsurface were similar to inorganics detected within the surface soils. The relatively low concentrations were within the Station-wide background levels.

The subsurface soil at Site 1 has not been significantly impacted by site operations. There is no apparent source or discernable pattern of contamination within this media. The leaching of

subsurface soil contaminants to groundwater is a potential contaminant migration pathway. Organic contaminants detected in groundwater at Site 1 have likely migrated through (or from) the subsurface soils. However, the analytical results from the subsurface soil samples collected during this investigation indicates that this media is not currently acting as a source of groundwater degradation at Site 1.

4.3.1.2 Groundwater

This section addresses the extent of groundwater contamination at Site 1. Figures 4-5 and 4-7 illustrate the extent of organic contaminants in groundwater. Possible sources of groundwater contamination and potential migration of contamination are also evaluated.

During the Round Two RI shallow and a deep monitoring wells were installed within the shallow (Columbia) and deeper (Cornwallis Cave/Yorktown Eastover) aquifer at Site 1 to determine the horizontal and vertical extent of groundwater contamination.

Results of the Round Two RI indicated that the horizontal extent of VOC contamination (chlorinated solvents) detected in the Round One RI at Site 1 is limited to the western portion of the landfill near 1GW12. The highest concentrations of TCE and 1,2-dichloroethene were detected in 1GW20 at 90B µg/L and 52B µg/L respectively (presented on Figure 4-5). These samples were collected from the Columbia aquifer.

Concentrations of inorganics in shallow groundwater were generally within the range of the Station-wide levels for both total and dissolved fractions (with the exception of cadmium that exceeded the Federal MCLs at one location for both the total and dissolved fractions).

VOC contamination (chlorinated solvents) was also detected within the deeper monitoring wells installed within the Cornwallis Cave/Yorktown Eastover aquifer. Concentrations of TCE were greatest (360 µg/L) within the shallow portions of the aquifer just below the Cornwallis Cave confining unit at 1GW12B. A groundwater sample collected within the deeper portions of the aquifer at 1GW12A showed a decrease of TCE concentrations (46B µg/L). The concentrations of TCE within this sample was qualified as a blank contaminant and the concentrations may be

regarded as nondetect (refer to Section 4.1.1); however, it is presented here as a conservative estimate of the vertical extent of groundwater contamination.

Although concentrations of chromium and lead exceeded the Federal MCLs, the inorganic concentrations detected in the deep groundwater were generally within the range of the Station-wide levels for both total and dissolved fractions.

As noted in Section 4.2.1.3 the concentrations of TCE and 1,2-DCE at monitoring well 1GW12 decreased between the Round One and Two sampling events. The following discussion will present an explanation for this difference. The Round one data (July, 1992) indicated the presence of TCE and 1, 2-DCE within monitoring well 1GW12 at concentrations of 18,000 µg/L and 1,000 µg/L, respectively. Prior to the development site-specific work plans the well was resampled (July 1995) to confirm the Round One data. The concentrations of TCE and 1,2-DCE were significantly lower at 3,900 µg/L and 520 µg/L, respectively.. Monitoring well 1GW12 was resampled during the Round Two RI (February, 1996) using low-flow techniques to minimize the agitation in the well, preventing volatilization and the entrainment of fine particulate matter in the sample matrix. TCE and 1,2-DCE were detected at concentrations of 64B µg/L and 40J µg/L, respectively. In addition, a shallow monitoring well (1GW19) upgradient of 1GW12 had detectable concentrations of TCE at 4J µg/L and the downgradient well 1GW20 had concentrations of TCE at 190 µg/L and 1,2-DCE at 52 µg/L. These concentrations support the Round Two results at well 1GW12. In addition, two deeper monitoring wells installed within the lower Cornwallis Cave/Yorktown-Eastover aquifer showed TCE concentrations of 360 µg/L (1GW12B at approximately 28 to 38 ft. bgs) and 46B µg/L (1GW12A at approximately 50 to 65 ft. bgs). The July and Round Two data for well 1GW12 indicate significant attenuation of TCE and 1,2-DCE in shallow groundwater. A possible explanation for the attenuation of TCE and 1,2-DCE may be the groundwater flow velocity and the proximity of well 1GW12 to a ravine located directly downgradient. The shallow groundwater flow velocity is approximately 1.2 feet per day toward the direction of the ravine. The higher concentrations of TCE detected during the Round One RI may have migrated toward the ravine emanating with the groundwater along the steep slope (damp to wet surface soil conditions were observed in this area during the Round Two field investigation). The horizontal component of contamination migration is likely more significant than the vertical component because the Round Two data did not indicate significant TCE contamination at depth. In addition, any vertical

migration of TCE may have migrated through a breach in the Cornwallis Cave confining unit that was eroded through the formation of the ravine.

Refer to Figures 4-11 and 4-12, for a graphical depiction of the the vertical extent of groundwater contamination. As shown on Figure 4-11, the concentrations of TCE and DCE decrease at depth and down gradient. This is supported by the decrease of TCE and DCE within the deeper monitoring well 1GW12A and the absence of these compounds in monitoring well 1GW04. The horizontal extent of groundwater contamination, as depicted on Figure 4-13, is limited to a small area in the southwest corner of the site. The data presented on these figures suggests that the lateral migration of shallow (Columbia) groundwater contaminants has been limited and that some vertical (Columbia to Cornwallis Cave/Yorktown-Eastover) migration has occurred.

4.3.1.3 Surface Water

The Round Two RI surface water analytical results were consistent with the Round One RI results; VOCs, SVOCs, and pesticides/PCBs were not detected in the surface water. Cadmium and copper slightly exceeded the Station-wide levels and Federal and Commonwealth of Virginia ambient water quality criteria in all three samples.

The surface water within the study area has not been significantly impacted by operations at Sites 1 and 3. There is no apparent source or discernable pattern of contamination in this media.

4.3.1.4 Sediment

Relatively low concentrations of inorganics were detected within the samples. No organic contaminants were detected. Only the concentrations of cadmium and copper exceeded Station-wide background levels. Concentrations of arsenic, cadmium, and lead slightly exceeded sediment screening values. Only arsenic was detected in more than one sample at both sample intervals.

The sediment within the study area has not been significantly impacted by operations at Sites 1 and 3. There is no apparent source or discernable pattern of contamination in this media.

4.3.2 Site 3

This section describes the extent to which contamination has migrated at Site 3 and the potential for future migration of contaminants.

4.3.2.1 Soil

The following subsections discuss the extent of surface and subsurface soil contamination at Site 3.

Surface Soil

Following evaluation of data collected during the Round One RI, low concentrations SVOCs were identified as soil contaminants across Site 3, this is consistent with the analytical results of the Round Two sampling event. The concentrations of SVOCs (mainly PAHs) were detected within two samples. One sample (3SS10) had elevated concentrations of PAHs located at the eastern portion of the site. Sample 3SB08A-00 also located at the eastern portion of the site had similar compounds detected but at significantly lower concentrations. The SVOCs detected are possibly related to past disposal practices.

One PCB compound (aroclor-1260) was detected at low concentrations at 3SS11 collected down gradient of a debris pile and may be attributed to past site operations. Low concentrations of pesticides were detected in one sample (3SB08A-00) are consistent with historical use of Station-wide spraying, consistent with historical use of Station-wide spraying.

Inorganic concentrations slightly exceeded Station-wide levels for arsenic and lead in one sample for each analyte.

Confirmation Sampling

The confirmatory surface soil samples collected around sample location 3SS10 (see Section 2.2.1.1 and Figure 2-1) indicated the presence of PAHs. The elevated concentrations of PAHs appears to be related to a "tar-like" substance observed during collection of the samples. These concentrations are limited to a small areal extent within the surficial (0- to 6-inches bgs) soil. In addition, the

concentrations decrease by an order of magnitude in the subsurface sample 3SB10B (1.5 - to 2.0 ft bgs).

The surface soil at Site 3 has not been significantly impacted by site operations. With the exception of sample location 3SS10, where PAH concentrations appear to be related to the "tar-like" substance.

Subsurface Soil

Low to moderate levels of VOCs were detected at two locations 3SB15A (15- to 17-feet bgs) and 3TP02 (including the duplicate) from 8- to 9-feet bgs. VOCs were not detected in 3SB15A at the 23-to 25 foot interval.

Relatively low concentrations of SVOCs were detected at 3SB15A at 23- to 25 feet bgs and at 3TP02 at 8- to 9-feet bgs. Low levels of pesticides were also detected at these same locations and depths. These contaminants may be the result of past disposal practices at the landfill.

Inorganics detected within the subsurface were similar to inorganics detected within the surface soils. The relatively low concentrations were within the Station-wide background levels.

The subsurface soil at Site 3 has not been significantly impacted by site operations. There is no apparent source or discernable pattern of contamination within this media. The leaching of subsurface soil contaminants to groundwater is a potential contaminant migration pathway. Organic contaminants detected in groundwater at Site 3 may have migrated through (or from) the subsurface soils. The analytical results from the subsurface soil samples collected during this investigation; however, indicates that this media is not currently acting as a source of groundwater degradation at Site 3.

4.3.1.2 Groundwater

This section addresses the extent of groundwater contamination at Site 3. Figures 4-7 illustrates the extent of organic contaminants in groundwater. Possible sources of groundwater contamination and potential migration of contamination are also evaluated.

During the Round Two RI shallow and deep monitoring wells were installed within the aquifer at Site 3 to determine the horizontal and vertical extent of groundwater contamination.

Results of the Round Two RI were consistent with VOC contamination (chlorinated solvents) detected in the Round One RI. The highest concentrations of VOCs were detected at 3GW19 installed within the shallow portions of the Cornwallis Cave/Yorktown-Eastover aquifer with concentrations of vinyl chloride at 48 µg/L, 1,1-dichloroethene at 4 µg/L, 1,2-dichloroethene at 570 µg/L, and trichloroethene at 860 µg/L.

The groundwater samples collected at greater depths within this same aquifer showed a significant decrease of VOC concentrations. The highest levels were located at 3GW19A (adjacent to 3GW19) which had concentrations of 1,2-dichloroethene at 24 µg/L and trichloroethene at 24 µg/L.

Concentrations of total inorganics in groundwater were generally within the range of the Station-wide levels except at 3GW19A where chromium exceeded the Federal and the Commonwealth of Virginia MCLs at a concentration of 177 µg/L and lead exceeded the Federal MCL at a concentration of 22 µg/L.

As depicted on Figure 4-11, the vertical extent of groundwater contamination at Site 3 appears to be limited to the upper portion of the Cornwallis Cave/Yorktown Eastover aquifer. There is a significant decrease in contaminant levels from shallow to deep portions of the aquifer. The horizontal extent of groundwater contamination, as depicted on Figure 4-13, covers the majority of the Site 3 area but is most pronounced (i.e., highest concentrations) to the north of the site.

Groundwater flow is generally toward Indian Field Creek, where groundwater discharge is likely (Figure 4-11). Surface water/sediment samples collected from Indian Field Creek during this investigation do not contain the organic contaminants that were detected in Site 3 groundwater. The data presented on these Figures 4-11 and 4-13 (along with surface water/sediment data collected from Indian Field Creek) suggests that the lateral migration of groundwater contaminants has been limited and that some vertical migration has occurred.

4.4 References

Baker Environmental, Inc. 1995. Summary of Background Constituent Concentrations and Characterization of the Biotic Community from the York River Drainage Basin, Naval Weapons Station Yorktown, Yorktown, Virginia Final. April, 1995.

United States Environmental Protection Agency. 1989. Risk Assessment Guidance for Superfund Volume I. Human Health Evaluation Manual (Part A) Interim Final. Office of Solid Waste and Emergency Response. Washington, D.C. December 1989. EPA/540/1-89-002.

TABLE 4-1
DATA QUALIFIER DEFINITIONS AND NOTES

NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

QUALIFIER DEFINITIONS

(NO CODE) = Confirmed identification.

B = Not detected substantially above the level reported in laboratory or field blanks.

J = Analyte present. Reported value may not be accurate or precise.

K = Analyte present. Reported value may be biased high. Actual value is expected lower.

L = Analyte present. Reported value may be biased low. Actual value is expected to be higher.

N = Tentative identification. Consider present. Special methods may be needed to confirm its presence or absence in future sampling efforts.

R = Unreliable result. Analyte may or may not be present in the sample. Supporting data necessary to confirm result.

U = Not detected. The associated number indicates approximate sample concentration necessary to be detected.

UJ = Not detected. Quantitation limit may be inaccurate or imprecise.

UL = Not detected. Quantitation limit is probably higher.

NOTES

mg/kg = milligrams per kilogram.

mg/l = milligrams per liter.

ug/kg = micrograms per kilogram.

ug/l = micrograms per liter.

NA = Not analyzed.

TABLE 4-2

STATION-WIDE AND SITE-SPECIFIC BACKGROUND INORGANIC CONCENTRATIONS DETECTED IN SURFACE AND SUBSURFACE SOILS SITES 1 AND 3 NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA

	Station-Wide Surface	Station-Wide Subsurface
Aluminum	1,960 - 19,200	2,710 - 28,200
Antimony	9.2L - 11L	8.5L - 31.3L
Arsenic	0.46L - 63.9	0.23J - 42.7
Barium	4.2J - 80.2	10.6J - 66.9
Beryllium	0.23J - 0.93J	0.3J - 9.8
Cadmium	1.3K - 1.5	ND
Chromium	2.6 - 18.3	5.2L - 33.5
Cobalt	1J - 6.7J	0.97J - 156
Copper	1.2J - 24.4	2J - 15
Cyanide	NA	0.6K
Iron	1,440 - 19,900	1,385 - 51,100J
Lead	6.4 - 43.1	3.6L - 25.5L
Magnesium	61.5J - 1,610	136J - 2,870
Manganese	7.6L - 491	3.5J - 2,940
Mercury	ND	ND
Nickel	3.8J - 11.9	4.2J - 145
Potassium	398J - 1,640J	3,92J - 2,560
Selenium	0.26L - 0.55L	0.26L - 0.75L
Silver	1J - 2.1J	1.1J - 2.4J
Sodium	13.9J - 115J	17.2J - 2,180
Thallium	ND	0.44K
Vanadium	6.1J - 34.7	7.8J - 70.3K
Zinc	3.2KJ - 48.4	3.6J - 330

Notes:

- All values in mg/kg (parts-per-million)

TABLE 4-3
SURFACE SOIL - POSITIVE DETECTION SUMMARY
ORGANIC COMPOUNDS
SITE 1
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION	1SB12A-00	1SB13A-00	1SB13AD-00	1SB18-00	1SB19-00	1SB20-00
DATE SAMPLED	01/24/96	01/23/96	01/23/96	01/24/96	01/23/96	01/23/96
DEPTH	0-0.5'	0-0.5'	0-0.5'	0-0.5'	0-0.5'	0-0.5'
SEMIVOLATILES (ug/kg)						
ACENAPHTHYLENE	46 J	380 U	380 U	380 U	390 U	360 U
2,4-DINITROTOLUENE	380 U	380 U	380 U	380 U	390 U	360 U
DIETHYLPHTHALATE	380 U	380 U	380 U	380 U	390 U	360 U
PHENANTHRENE	380 U	380 U	380 U	380 U	390 U	360 U
ANTHRACENE	380 U	380 U	380 U	380 U	390 U	360 U
FLUORANTHENE	390	380 U	380 U	380 U	70 J	360 U
PYRENE	470	380 U	380 U	380 U	76 J	360 U
BUTYLBENZYLPHTHALATE	380 U	380 U	380 U	380 U	390 U	360 U
BENZO(A)ANTHRACENE	400	380 U	380 U	380 U	47 J	360 U
CHRYSENE	480	380 U	380 U	380 U	64 J	360 U
BIS(2-ETHYLHEXYL)PHTHALATE	380 U	380 U	380 U	380 U	120 J	360 U
BENZO(B)FLUORANTHENE	690	380 U	380 U	48 J	100 J	360 U
BENZO(K)FLUORANTHENE	260 J	380 U	380 U	380 U	43 J	360 U
BENZO(A)PYRENE	380 J	380 U	380 U	380 U	69 J	360 U
INDENO(1,2,3-CD)PYRENE	300 J	380 U	380 U	380 U	79 J	360 U
DIBENZO(A,H)ANTHRACENE	73 J	380 U	380 U	380 U	390 U	360 U
BENZO(G,H,I)PERYLENE	260 J	380 U	380 U	380 U	73 J	360 U
PESTICIDE/PCBS (ug/kg)						
DIELDRIN	3.8 U	3.8 UJ	3.8 U	3.7 U	9.8 J	3.6 U
4,4'-DDT	3.8 U	3.8 UJ	3.8 U	3.7 U	2 J	3.6 U
ALPHA-CHLORDANE	1.9 U	1.9 UJ	1.9 U	1.9 U	2 J	1.8 U
GAMMA-CHLORDANE	1.9 U	1.9 UJ	1.9 U	1.9 U	1.2 J	1.8 U
AROCLOR-1260	38 U	38 UJ	38 U	35 J	39 UJ	36 U

TABLE 4-3
SURFACE SOIL - POSITIVE DETECTION SUMMARY
ORGANIC COMPOUNDS
SITE 1
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION	1SB21-00	1SS07	1SS07D	1SS08	1SS09	1SS10
DATE SAMPLED	01/24/96	01/24/96	01/24/96	01/24/96	01/24/96	01/23/96
DEPTH	0-0.5'	0-0.5'	0-0.5'	0-0.5'	0-0.5'	0-0.5'
SEMIVOLATILES (ug/kg)						
ACENAPHTHYLENE	480 U	400 U	390 U	370 U	400 U	360 U
2,4-DINITROTOLUENE	480 U	400 U	390 U	370 U	400 U	360 U
DIETHYLPHTHALATE	480 U	310 J	390 U	370 U	400 U	360 U
PHENANTHRENE	480 U	400 U	390 U	370 U	400 U	360 U
ANTHRACENE	480 U	400 U	390 U	370 U	400 U	360 U
FLUORANTHENE	480 U	100 J	150 J	190 J	400 U	60 J
PYRENE	480 U	120 J	160 J	180 J	400 U	53 J
BUTYLBENZYLPHTHALATE	480 U	400 U	390 U	370 U	40 J	360 U
BENZO(A)ANTHRACENE	480 U	56 J	77 J	84 J	400 U	360 U
CHRYSENE	480 U	96 J	120 J	110 J	400 U	360 U
BIS(2-ETHYLHEXYL)PHTHALATE	480 U	400 U	390 U	43 J	400 U	360 U
BENZO(B)FLUORANTHENE	480 U	140 J	180 J	160 J	400 U	48 J
BENZO(K)FLUORANTHENE	480 U	64 J	78 J	67 J	400 U	360 U
BENZO(A)PYRENE	480 U	70 J	93 J	70 J	400 U	360 U
INDENO(1,2,3-CD)PYRENE	480 U	75 J	98 J	72 J	400 U	360 U
DIBENZO(A,H)ANTHRACENE	480 U	400 U	390 U	370 U	400 U	360 U
BENZO(G,H,I)PERYLENE	480 U	60 J	77 J	54 J	400 U	360 U
PESTICIDE/PCBS (ug/kg)						
DIELDRIN	4.8 U	4 U	3.9 U	3.8 U	4 U	3.6 U
4,4'-DDT	4.8 U	4 U	3.9 U	3.8 U	4 U	3.6 U
ALPHA-CHLORDANE	2.4 U	2 U	2 U	1.9 U	2 U	1.8 U
GAMMA-CHLORDANE	2.4 U	2 U	2 U	1.9 U	2 U	1.8 U
AROCLOR-1260	48 U	40 U	39 U	38 U	40 U	36 U

TABLE 4-3
SURFACE SOIL - POSITIVE DETECTION SUMMARY
ORGANIC COMPOUNDS
SITE 1
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION	1SS11	1SS12	1SS13	1SS14	1SS14D	1SS15
DATE SAMPLED	01/23/96	01/23/96	01/23/96	01/23/96	01/23/96	01/23/96
DEPTH	0-0.5'	0-0.5'	0-0.5'	0-0.5'	0-0.5'	0-0.5'
SEMIVOLATILES (ug/kg)						
ACENAPHTHYLENE	360 U	380 U	380 U	360 U	360 U	350 U
2,4-DINITROTOLUENE	360 U	380 U	68 J	360 U	360 U	350 U
DIETHYLPHTHALATE	360 U	380 U	380 U	360 U	360 U	350 U
ANTHRACENE	360 U	380 U	380 U	360 U	360 U	350 U
FLUORANTHENE	360 U	380 U	380 U	360 U	360 U	350 U
PYRENE	360 U	380 U	380 U	360 U	360 U	350 U
BUTYLBENZYLPHTHALATE	240 J	380 U	380 U	360 U	360 U	350 U
BENZO(A)ANTHRACENE	360 U	380 U	380 U	360 U	360 U	350 U
CHRYSENE	360 U	380 U	380 U	360 U	360 U	350 U
BIS(2-ETHYLHEXYL)PHTHALATE	6500	380 U	38 J	360 U	360 U	350 U
BENZO(B)FLUORANTHENE	360 U	380 U	380 U	360 U	360 U	350 U
BENZO(K)FLUORANTHENE	360 U	380 U	380 U	360 U	360 U	350 U
BENZO(A)PYRENE	360 U	380 U	380 U	360 U	360 U	350 U
INDENO(1,2,3-CD)PYRENE	360 U	380 U	380 U	360 U	360 U	350 U
DIBENZO(A,H)ANTHRACENE	360 U	380 U	380 U	360 U	360 U	350 U
BENZO(G,H,I)PERYLENE	360 U	380 U	380 U	360 U	360 U	350 U
PESTICIDE/PCBS (ug/kg)						
DIELDRIN	3.6 U	3.8 U	3.8 U	3.6 U	3.6 U	3.5 U
4,4'-DDT	3.6 U	3.8 U	3.8 U	3.6 U	3.6 U	3.5 U
ALPHA-CHLORDANE	1.8 U	1.9 U	1.9 U	1.8 U	1.8 U	1.8 U
GAMMA-CHLORDANE	1.8 U	1.9 U	1.9 U	1.8 U	1.8 U	1.8 U
AROCLOR-1260	36 U	38 U	38 U	36 U	36 U	35 U

TABLE 4-3
SURFACE SOIL - POSITIVE DETECTION SUMMARY
ORGANIC COMPOUNDS
SITE 1
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION	1SS16	1SS17	1SS18
DEPTH	0-0.5'	0-0.5'	0-0.5'
SEMIVOLATILES (ug/kg)			
ACENAPHTHYLENE	350 U	380 U	370 U
2,4-DINITROTOLUENE	350 U	380 U	370 U
DIETHYLPHTHALATE	350 U	380 U	370 U
PHENANTHRENE	350 U	200 J	370 U
ANTHRACENE	350 U	39 J	370 U
FLUORANTHENE	350 U	230 J	64 J
PYRENE	350 U	190 J	52 J
BUTYLBENZYLPHTHALATE	350 U	380 U	370 U
BENZO(A)ANTHRACENE	350 U	98 J	370 U
CHRYSENE	350 U	100 J	56 J
BIS(2-ETHYLHEXYL)PHTHALATE	52 J	380 U	370 U
BENZO(B)FLUORANTHENE	350 U	140 J	75 J
BENZO(K)FLUORANTHENE	350 U	71 J	370 U
BENZO(A)PYRENE	350 U	73 J	370 U
INDENO(1,2,3-CD)PYRENE	350 U	70 J	49 J
DIBENZO(A,H)ANTHRACENE	350 U	380 U	370 U
BENZO(G,H,I)PERYLENE	350 U	65 J	42 J
PESTICIDE/PCBS (ug/kg)			
DIELDRIN	3.5 U	3.8 U	3.7 U
4,4'-DDT	3.5 U	3.8 U	3.7 U
ALPHA-CHLORDANE	1.8 U	1.9 U	1.9 U
GAMMA-CHLORDANE	1.8 U	1.9 U	1.9 U
AROCLOR-1260	35 U	38 U	37 U

TABLE 4-4
SURFACE SOIL - POSITIVE DETECTION SUMMARY
INORGANICS
SITE 1
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION	1SB12A-00	1SB13A-00	1SB13AD-00	1SB18-00	1SB19-00	1SB20-00
DATE SAMPLED	01/24/96	01/23/96	01/23/96	01/24/96	01/23/96	01/23/96
DEPTH	0-0.5'	0-0.5'	0-0.5'	0-0.5'	0-0.5'	0-0.5'
INORGANICS (mg/kg)						
ALUMINUM	6950	4520	4550	11200	5600	1930
ARSENIC	92.5	1.1	0.99	7.2	6.1	0.64 L
BARIUM	28.1	25.6	27.6	32.8	27.6	19.8
BERYLLIUM	0.33	0.37	0.3	0.47	0.55	0.21
CADMIUM	0.45 U	0.37 U	0.47 U	0.36 U	0.37 U	0.39 U
CALCIUM	476	87.6	119	620	1000	516
CHROMIUM	8.1	3.9 K	4.2	12.3	7.5	3.4 K
COBALT	2.1	1.2	1.3	3.2	2.3	4.2
COPPER	3.1	2.1	2.5	4	3.6	1.8
IRON	7790	3530	3610	11700	5450	2510
LEAD	6.4 K	6.3 K	6.2 K	8.7 K	62.3 K	3.8
MAGNESIUM	491	284	280	848	424	229
MANGANESE	87	70.6	81.2	81	117	65.2
NICKEL	4.5 K	2.3 K	3 K	7.3 K	5.6 K	3.9
POTASSIUM	287 K	138 U	178 U	423 K	370 K	147 U
SELENIUM	0.29 UL	0.29 UL	0.28 L	0.26 UL	0.28 UL	0.22 U
VANADIUM	13	7.6	7.7	20	10.8	5.6
ZINC	14.5	11.2	11.6	16	24.8	19.5

TABLE 4-4
SURFACE SOIL - POSITIVE DETECTION SUMMARY
INORGANICS
SITE 1
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION	1SB21-00	1SS07	1SS07D	1SS08	1SS09	1SS10
DATE SAMPLED	01/24/96	01/24/96	01/24/96	01/24/96	01/24/96	01/23/96
DEPTH	0-0.5'	0-0.5'	0-0.5'	0-0.5'	0-0.5'	0-0.5'
INORGANICS (mg/kg)						
ALUMINUM	3090	3690	3440	3980	3550	4130
ARSENIC	1.4	1.7	1.9	1.3	3.1	2.1
BARIUM	13.9	20.9	22.8	17	10.8	15.2
BERYLLIUM	0.27	0.22	0.28	0.25	0.26	0.21
CADMIUM	0.43 U	0.42 U	0.47 U	0.43 U	0.5 U	0.37 U
CALCIUM	165	744	904	417	175	773
CHROMIUM	6	5.1	4.4	5.1	5.4	6.2
COBALT	1.7	0.9	1.2	0.98	1.1	1.1
COPPER	1.8	6.2	5	2.2	2	4
IRON	5300	4220	4000	4480	5620	5490
LEAD	5.6 K	9.9	9.4	5	3.8	7.7
MAGNESIUM	285	360 J	324 J	356 J	231 J	375 J
MANGANESE	30.5	48.1 J	57.2 J	22.9 J	16.8 J	29.7 J
NICKEL	4.3 K	3.3 K	2.4 U	3.9 K	4.9 K	2.9 K
POTASSIUM	310 K	267	248	361	189 U	299
SELENIUM	0.36 UL	0.25 UL	0.25 UL	0.21 UL	0.31 UL	0.21 UL
VANADIUM	10.3	7.4	6.7	7.7	10.8	8.3
ZINC	12.8	19.6	21.2	15	7.7 K	18.2

TABLE 4-4
SURFACE SOIL - POSITIVE DETECTION SUMMARY
INORGANICS
SITE 1
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION	1SS11	1SS12	1SS13	1SS14	1SS14D	1SS15
DATE SAMPLED	01/23/96	01/23/96	01/23/96	01/23/96	01/23/96	01/23/96
DEPTH	0-0.5'	0-0.5'	0-0.5'	0-0.5'	0-0.5'	0-0.5'
INORGANICS (mg/kg)						
ALUMINUM	2990	4690	6630	4680	4240	2820
ARSENIC	1.6	2.7	3.1	1.7 L	1.4 L	1.2 L
BARIUM	10.1	15.2	25.1	11.4	11.6	9.7
BERYLLIUM	0.15 U	0.15 U	0.28	0.14 U	0.14 U	0.14 U
CADMIUM	0.41 U	0.47 K	0.44 U	0.39 U	0.39 U	0.38 U
CALCIUM	96.6	1390	1550	305	320	102
CHROMIUM	4.6	9	12.4	5	4.8	3.9 K
COBALT	0.55 U	1.7	1.7	0.53 U	0.69	0.52 U
COPPER	1.9	4.8	14.6	2	2	2.1
IRON	3970	7100	9310	4210	3980	3280
LEAD	4.1	9.3 K	18.6	3.8	3.5	5.3
MAGNESIUM	202 J	546 J	888 J	279	254	170
MANGANESE	17.2 J	42.2 J	63.1 J	21.1	20.4	18.2
NICKEL	2.1 U	3.8 K	5.3 K	2 U	2.3	2 U
POTASSIUM	233	578	881	253	222	200
SELENIUM	0.24 UL	0.25 UL	0.24 UL	0.23 U	0.22 U	0.23 U
VANADIUM	6.7	11.2	15	8.8	8.2	7.2
ZINC	8.5	24	43.5	7.2 K	7 K	7.6 K

TABLE 4-4
SURFACE SOIL - POSITIVE DETECTION SUMMARY
INORGANICS
SITE 1
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION	1SS16	1SS17	1SS18
DATE SAMPLED	01/23/96	01/23/96	01/23/96
DEPTH	0-0.5'	0-0.5'	0-0.5'
INORGANICS (mg/kg)			
ALUMINUM	2030	7390	8950
ARSENIC	1.3 L	3.8 L	43.5 L
BARIUM	6.1	33.6	29.6
BERYLLIUM	0.14 U	0.37	0.39
CADMIUM	0.38 U	0.42 U	0.4 U
CALCIUM	118	2250	647
CHROMIUM	4.1	11.1	10.1
COBALT	0.52 U	3.1	2
COPPER	1.3	5	3.1
IRON	3070	7740	10100
LEAD	2.8	12	7.6
MAGNESIUM	142	614	469
MANGANESE	17.6	126	84.9
NICKEL	1.9 U	3.7	5.9
POTASSIUM	198	495	315
SELENIUM	0.23 U	0.25 U	0.24 U
VANADIUM	6.4	15	17.6
ZINC	4.4 K	26.1	13.6

TABLE 4-5
SUBSURFACE SOIL - POSITIVE DETECTION SUMMARY
ORGANIC COMPOUNDS
SITE 1
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION	1SB12A-01	1SB12AD-01	1SB13A-01	1SB13AD-01	1SB18-01	1SB19-01
DATE SAMPLED	01/24/96	01/24/96	01/25/96	01/25/96	01/24/96	01/23/96
DEPTH	1-3'	1-3'	1-3'	1-3'	1-3'	1-3'
VOLATILES (ug/kg)						
ACETONE	11 U	11 U	11 U	11 U	53 B	11 U
SEMIVOLATILES (ug/kg)						
DIETHYLPHTHALATE	380 U	360 U	120 J	360 U	370 U	370 U
PHENANTHRENE	54 J	360 U	360 U	360 U	370 U	370 U
DI-N-BUTYLPHTHALATE	380 U	360 U	360 U	360 U	200 J	370 U
FLUORANTHENE	300 J	83 J	360 U	360 U	100 J	370 U
PYRENE	310 J	100 J	360 U	360 U	120 J	370 U
BENZO(A)ANTHRACENE	120 J	46 J	360 U	360 U	63 J	370 U
CHRYSENE	210 J	85 J	360 U	360 U	96 J	370 U
BIS(2-ETHYLHEXYL)PHTHALATE	380 U	360 U	39 J	360 U	310 J	140 J
BENZO(B)FLUORANTHENE	270 J	130 J	360 U	360 U	120 J	370 U
BENZO(K)FLUORANTHENE	120 J	57 J	360 U	360 U	55 J	370 U
BENZO(A)PYRENE	130 J	59 J	360 U	360 U	59 J	370 U
INDENO(1,2,3-CD)PYRENE	140 J	66 J	360 U	360 U	70 J	370 U
BENZO(G,H,I)PERYLENE	120 J	61 J	360 U	360 U	60 J	370 U
PESTICIDE/PCBS (ug/kg)						
DIELDRIN	3.8 UJ	3.6 UJ	3.6 U	3.6 U	3.7 U	4 J
4,4'-DDE	3.8 UJ	3.6 UJ	3.6 U	3.6 U	3.7 U	16 J
4,4'-DDD	3.8 UJ	3.6 UJ	3.6 U	3.6 U	3.7 U	7.4 J
4,4'-DDT	3.8 UJ	3.6 UJ	3.6 U	3.6 U	3.7 U	48 J
ALPHA-CHLORDANE	1.9 UJ	1.8 UJ	1.8 U	1.8 U	1.9 U	4.4 J
GAMMA-CHLORDANE	1.9 UJ	1.8 UJ	1.8 U	1.8 U	1.9 U	3.7 J
AROCLOR-1260	38 UJ	36 UJ	36 U	36 U	37 U	37 UJ

SUBSURFACE SOIL - POSITIVE DETECTION SUMMARY
ORGANIC COMPOUNDS
SITE 1
NAVAL WEAPONS STATION YORKTOWN

TABLE 4-5
SUBSURFACE SOIL - POSITIVE DETECTION SUMMARY
ORGANIC COMPOUNDS
SITE 1
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION	1TP03	1TP04	1TP04D
DATE SAMPLED	01/25/96	01/25/96	01/25/96
DEPTH	7-8'	7-8'	7-8'
VOLATILES (ug/kg)			
ACETONE	11 U	12 U	12 U
SEMIVOLATILES (ug/kg)			
DIETHYLPHTHALATE	350 U	410 U	400 U
PHENANTHRENE	350 U	410 U	400 U
DI-N-BUTYLPHTHALATE	350 U	410 U	400 U
FLUORANTHENE	350 U	410 U	400 U
PYRENE	350 U	410 U	400 U
BENZO(A)ANTHRACENE	350 U	410 U	400 U
CHRYSENE	350 U	410 U	400 U
BIS(2-ETHYLHEXYL)PHTHALATE	160 B	410 U	46 B
BENZO(B)FLUORANTHENE	350 U	410 U	400 U
BENZO(K)FLUORANTHENE	350 U	410 U	400 U
BENZO(A)PYRENE	350 U	410 U	400 U
INDENO(1,2,3-CD)PYRENE	350 U	410 U	400 U
BENZO(G,H,I)PERYLENE	350 U	410 U	400 U
PESTICIDE/PCBS (ug/kg)			
DIELDRIN	3.6 U	4.1 U	4 U
4,4'-DDE	3.6 U	4.1 U	4 U
4,4'-DDD	3.6 U	4.1 U	4 U
4,4'-DDT	3.6 U	4.1 U	4 U
ALPHA-CHLORDANE	1.8 U	2 U	2 U
GAMMA-CHLORDANE	1.8 U	2 U	2 U
AROCLOR-1260	36 U	41 U	40 U

TABLE 4-6
SUBSURFACE SOIL - POSITIVE DETECTION SUMMARY
INORGANICS
SITE 1
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION	1SB12A-01	1SB12AD-01	1SB13A-01	1SB13AD-01	1SB18-01	1SB19-01
DEPTH	1-3	1-3	1-3	1-3	1-3	1-3
INORGANICS (ug/kg)						
ALUMINUM	2970	3830	7230	6730	7690	5250
ANTIMONY	3.5 UL	4.3 UL	4 UL	3.6 UL	3.1 UL	3.6 UL
ARSENIC	24.2 L	126 L	1.9	1.5	36 L	2.3 L
BARIUM	13.9 J	20.1 J	21.8	28.6	26.2 J	53.4 J
BERYLLIUM	0.23	0.27	0.28	0.17	0.38	0.18
CADMIUM	0.44	0.48 U	0.45 U	0.4 U	0.34 U	1.2
CALCIUM	542	371	82.1	80.3	702	1350
CHROMIUM	3.5 K	5	10.2	7.3	9	9.9
COBALT	1	1.5	1.9	2.2	2.2	1.8
COPPER	2.3	2	4.9	1.9	3.9	14.2
IRON	3920	5020	7630	6230	9450	7560
LEAD	3.3	5.8	4.3 K	3.9 K	5.8	57.4
MAGNESIUM	216	306	378	436	505	404
MANGANESE	49.1	82.2	38.3	44	97.5	65
NICKEL	3.5 K	3 K	2.8	3.4	5.1 K	4.9 K
POTASSIUM	148 U	192	167 UL	166 L	303	254
SELENIUM	0.27 UL	0.26 UL	0.23 U	0.25 U	0.23 UL	0.29 UL
SODIUM	18.6 B	18.1 B	4.9 B	10 B	16.7 B	19.7 B
VANADIUM	6	7.3	12.6	11.5	14.2	13.7
ZINC	52	11.2	16.4	11.5	13.5	187

TABLE 4-6
SUBSURFACE SOIL - POSITIVE DETECTION SUMMARY
INORGANICS
SITE 1
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION	1SB19-02	1SB20-01	1SB21-06	1SB21-09	1TP01	1TP02
DATE SAMPLED	01/23/96	01/23/96	01/24/96	01/24/96	01/25/96	01/25/96
DEPTH	3-5'	11-13'	17-19'	20-23'	4-5'	7-8'
INORGANICS (ug/kg)						
ALUMINUM	2590	1630	13000	9660	1450	3110
ANTIMONY	3 UL	3.5 UL	5.6 UL	4.4 L	3.9 UL	3 UL
ARSENIC	1 L	0.32 L	8.2	8.8	0.51	1.2
BARIUM	8.4 J	10.1 J	40.1	27.1	5.3	14.3
BERYLLIUM	0.12	0.24	1.1	0.75	0.16 U	0.14
CADMIUM	1.2	0.39 U	0.62 U	0.47 U	0.43 U	0.33 U
CALCIUM	284	128	512	407	125	396
CHROMIUM	3.8 K	2.3 K	34.5	27.4	2.7 B	3.5
COBALT	0.73	2.5	5.3	11.7	0.59 U	0.73
COPPER	1.8	1.1	8.2	7.9	0.4	1.1
IRON	3020	2010	25700	26300	1660	3920
LEAD	9.8	1.1	17.3 K	9.4 K	4.8	3.7
MAGNESIUM	138	158	2580	2320	97.9	193
MANGANESE	13.7	23.6	43.3	364	3.2 K	22.6
NICKEL	2.1 K	2 K	3.3	13.7	2.2 U	1.7 U
POTASSIUM	146	145 U	2460	1870 L	162 UL	126 UL
SELENIUM	0.27 UL	0.22 UL	0.5	0.3 U	0.24 U	0.24 U
SODIUM	12.3 B	16.1 B	44.2	35.6 B	4.2 U	3.3 U
VANADIUM	6	2.6	18.9	24.3	2.4	5.8
ZINC	58.1	8.7	53.1	60.3	2 K	5.5 K

TABLE 4-6
SUBSURFACE SOIL - POSITIVE DETECTION SUMMARY
INORGANICS
SITE 1
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION	1TP03	1TP04	1TP04D
DATE SAMPLED	01/25/96	01/25/96	01/25/96
DEPTH	7-8'	7-8'	7-8'
INORGANICS (ug/kg)			
ALUMINUM	801	2590	1170
ANTIMONY	3.1 UL	4.1 UL	4.3 UL
ARSENIC	0.64	2.7	1.3
BARIUM	3	7.6	4
BERYLLIUM	0.13	0.17 U	0.23
CADMIUM	0.34 U	0.46 U	0.47 U
CALCIUM	75.5	303	174
CHROMIUM	2.7 B	5.1	3.2 B
COBALT	0.47 U	0.62 U	1
COPPER	0.81	0.9	0.77
IRON	2160	4620	2080
LEAD	2.6	3.2	2
MAGNESIUM	92.2	297	175
MANGANESE	7.4	9.9	5.4
NICKEL	1.8 U	2.4 U	2.4 U
POTASSIUM	128 UL	368 L	179 UL
SELENIUM	0.22 U	0.26 U	0.25 U
SODIUM	3.3 U	7.5 B	6.3 B
VANADIUM	2.7	7.7	3.4
ZINC	6.6 K	6.7 K	6.5 K

TABLE 4-7
SUBSURFACE SOIL - POSITIVE DETECTION SUMMARY
ENGINEERING PARAMETERS
SITE 1
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION	1SB12A 15-19'	1SB12A-01	1SB12AD-01	1SB13A 33-37'	1SB13A-01	1SB13AD-01	1SB18-01	1SB19-01
DATE SAMPLED	01/26/96	01/24/96	01/24/96	01/28/96	01/25/96	01/25/96	01/24/96	01/23/96
DEPTH	15-19'	1-3'	1-3'	33-37'	1-3'	1-3'	1-3'	1-3'
ENGINEERING								
TOTAL ORGANIC CARBON (%)	0.21	NA	NA	0.7	NA	NA	0.39	NA
% SOLIDS	76.6	87.2	91.3	78.9	92.4	90.2	88.1	89.8

TABLE 4-7
SUBSURFACE SOIL - POSITIVE DETECTION SUMMARY
ENGINEERING PARAMETERS
SITE 1
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION	1SB19-02	1SB20-01	1SB21-06	1SB21-09
DATE SAMPLED	01/23/96	01/23/96	01/24/96	01/24/96
DEPTH	3-5'	1-3'	11-14'	20-23'
ENGINEERING				
TOTAL ORGANIC CARBON (%)	NA	NA	NA	NA
% SOLIDS	91.7	93.6	56.4	66.7

TABLE 4-8
SHALLOW GROUNDWATER - POSITIVE DETECTION SUMMARY
ORGANIC COMPOUNDS
SITE 1
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION	11GW11-01	1GW04-01	1GW04-01D	1GW05-01	1GW12-01	1GW13-01
DATE SAMPLED	02/10/96	02/10/96	02/10/96	02/10/96	02/09/96	02/10/96
VOLATILES (ug/L)						
1,2-DICHLOROETHENE (TOTAL)	10 U	10 U	10 U	10 U	40 B	10 U
TRICHLOROETHENE	10 U	10 U	10 U	10 U	64 B	10 U
SEMIVOLATILES (ug/L)						
NITROBENZENE	10 U	10 U	10 U	10 U	10 U	10 U
PENTACHLOROPHENOL	1 J	24 U	25 U	24 U	24 U	25 U
NITRAMINES (ug/L)						
NITROBENZENE	0.14 U	0.35 U	0.32 U	0.36 U	0.27 U	0.24 U

TABLE 4-8
SHALLOW GROUNDWATER - POSITIVE DETECTION SUMMARY
ORGANIC COMPOUNDS
SITE 1
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION	1GW14-01	1GW17-01	1GW18-01	1GW19-01	1GW20-01
DATE SAMPLED	02/08/96	02/08/96	02/09/96	02/09/96	02/10/96
VOLATILES (ug/L)					
1,2-DICHLOROETHENE (TOTAL)	10 U	10 U	10 U	10 U	52
TRICHLOROETHENE	10 U	10 U	10 U	4 J	190
SEMIVOLATILES (ug/L)					
NITROBENZENE	3 J	1 J	2 J	10 U	9 U
PENTACHLOROPHENOL	24 U	24 U	24 U	25 U	24 U
NITRAMINES (ug/L)					
NITROBENZENE	1.4	0.7	1.3	0.22 U	0.16 U

TABLE 4-9
SHALLOW GROUNDWATER - POSITIVE DETECTION SUMMARY
INORGANICS
SITE 1
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION	11GW11-01	1GW04-01	1GW04-01D	1GW05-01	1GW12-01	1GW13-01
DATE SAMPLED	02/10/96	02/10/96	02/10/96	02/10/96	02/09/96	02/10/96
TOTAL METALS (ug/L)						
ALUMINUM, TOTAL	294 B	716	1080	652	47.8	449
ARSENIC, TOTAL	0.9 U	1.7 L	2.1 L	1.3 L	1.1 L	0.9 UL
BARIUM, TOTAL	58.4	39.8	39.9	14.2	98.8	40.7
CADMIUM, TOTAL	2.2 U	2.2 U	2.2 U	2.2 U	8.6	2.2 U
CALCIUM, TOTAL	4210	103000	99800	24200	81500	4280
CHROMIUM, TOTAL	2.4 U	2.4 U	2.4 U	2.4 U	2.4 U	2.4 U
COBALT, TOTAL	6.6	3 U	3 U	9.3	3 U	3 U
COPPER, TOTAL	2 U	2 U	2 U	2 U	8.6	6.3
IRON, TOTAL	229	1600	1990	5060	909	2520
LEAD, TOTAL	0.95	1.5	0.8 U	1.6	4.7	3.1
MAGNESIUM, TOTAL	772	5540	5390	13500	6920	1540
MANGANESE, TOTAL	8.3 B	29	27.4	99.5	821	73.9
POTASSIUM, TOTAL	828 U	2540 L	2550 L	1420 L	2960 L	1260 L
SELENIUM, TOTAL	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U
SODIUM, TOTAL	2390	10900	10600	7940	3270	2070
VANADIUM, TOTAL	2.4 U	3.4	4.1	3.3	2.4 U	2.4 U
ZINC, TOTAL	4.8	3.6 UL	5.4 L	3.6 UL	2960	3.6 UL

TABLE 4-9
SHALLOW GROUNDWATER - POSITIVE DETECTION SUMMARY
INORGANICS
SITE 1
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION	1GW14-01	1GW17-01	1GW18-01	1GW19-01	1GW20-01
DATE SAMPLED	02/08/96	02/08/96	02/09/96	02/09/96	02/10/96
TOTAL METALS (ug/L)					
ALUMINUM, TOTAL	1310	968	23.3 U	2200	217 B
ARSENIC, TOTAL	0.9 U	0.9 U	3.5	3.9	0.9 U
BARIUM, TOTAL	67.5	16.2	97.1	52.7	25.4
CADMIUM, TOTAL	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U
CALCIUM, TOTAL	2150	14200	23000	94400	23200
CHROMIUM, TOTAL	2.4 U	2.4 U	2.4 U	6.4	2.4 U
COBALT, TOTAL	11.2	3 U	3 U	3.4	3.3
COPPER, TOTAL	2 U	2 U	2 U	2.8	2.6
IRON, TOTAL	407	1210	55300	3840	304
LEAD, TOTAL	3.6	1	1.1	2.3	0.86
MAGNESIUM, TOTAL	1030	4220	3580	5350	4620
MANGANESE, TOTAL	47.9	90.6	1500	71.8	6.6 B
POTASSIUM, TOTAL	828 U	1250	1370 L	3010	2910
SELENIUM, TOTAL	1.3 U	1.3 U	1.5	1.3 U	1.3 U
SODIUM, TOTAL	3530	3470	2240	2480	4430
VANADIUM, TOTAL	2.7	4.3	2.4 U	7.8	3.7
ZINC, TOTAL	11.9	3.6 U	6.1 L	30.1	10.1

TABLE 4-9
SHALLOW GROUNDWATER - POSITIVE DETECTION SUMMARY
DISSOLVED INORGANICS
SITE 1
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION	11GW11F-01	1GW04F-01	1GW04F-01D	1GW05F-01	1GW12F-01	1GW13F-01
DATE SAMPLED	02/10/96	02/10/96	02/10/96	02/10/96	02/09/96	02/10/96
DISSOLVED INORGANICS (ug/L)						
ALUMINUM, SOLUBLE	160 B	23.3 U	23.3 U	432	23.3 U	53.6
ARSENIC, SOLUBLE	0.9 U	0.9 UL	1.2 L	1.8 L	0.9 UL	0.9 UL
BARIUM, SOLUBLE	56.4	34.4	35	12.3	94.1	39.1
CADMIUM, SOLUBLE	2.2 U	2.2 U	2.2 U	2.2 U	9	2.2 U
CALCIUM, SOLUBLE	4210	94700	96600	24100	79000	4150
COBALT, SOLUBLE	5.4	3 U	3 U	9	3 U	3 U
COPPER, SOLUBLE	2	2 U	2 U	2 U	4.6	2 U
IRON, SOLUBLE	48.1 B	108	101	4760	23.9	853
LEAD, SOLUBLE	3.3	0.8 U	1.1	0.8 U	0.8 U	0.93
MAGNESIUM, SOLUBLE	777	4880	5050	13500	6660	1500
MANGANESE, SOLUBLE	8.5 B	24.6	23.6	102	803	71.3
NICKEL, SOLUBLE	11.3 U	11.3 U	11.3 U	12.2	11.3 U	11.3 U
POTASSIUM, SOLUBLE	828 U	1390 L	1780 L	932 L	2710 L	1260 L
SODIUM, SOLUBLE	2440	10100	10400	7930	3110	2130
VANADIUM, SOLUBLE	2.4 U	2.4 UL	2.4 U	2.4 U	2.4 U	2.4 U
ZINC, SOLUBLE	3.6 U	3.6 U	3.6 UL	4.4 L	2850	3.6 UL

TABLE 4-9
SHALLOW GROUNDWATER - POSITIVE DETECTION SUMMARY
DISSOLVED INORGANICS
SITE 1
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION	1GW14F-01	1GW17F-01	1GW18F-01	1GW19F-01	1GW20F-01
DATE SAMPLED	02/08/96	02/08/96	02/09/96	02/09/96	02/10/96
DISSOLVED INORGANICS (ug/L)					
ALUMINUM, SOLUBLE	966	255 B	383	29.4 B	51.6 B
ARSENIC, SOLUBLE	0.9 U	0.9 U	4.4 L	1.7	0.9 U
BARIUM, SOLUBLE	66.1	13.4	101	47.7	30.2
CADMIUM, SOLUBLE	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U
CALCIUM, SOLUBLE	2190	13600	23700	94400	20800
COBALT, SOLUBLE	14.2	4.7	5.7	4.1	3.6
COPPER, SOLUBLE	2 U	2 U	2 U	2.4	27.6
IRON, SOLUBLE	31.6 B	95.9 B	54900	1970	54.8 B
LEAD, SOLUBLE	1.6	0.8 U	1.7 K	0.8 U	1.5 U
MAGNESIUM, SOLUBLE	1000	4060	3680	5220	4650
MANGANESE, SOLUBLE	48.1	84.3	1530	64.8	10.3 B
NICKEL, SOLUBLE	11.3 U	11.3 U	11.3 U	11.3 U	11.3 U
POTASSIUM, SOLUBLE	847	1020	2000	2490	2390
SODIUM, SOLUBLE	3570	3380	2270	2430	4410
VANADIUM, SOLUBLE	2.4 U	2.4 U	2.4 U	2.4 U	2.4
ZINC, SOLUBLE	11.9	3.6 U	14.8	28.3	31.8

TABLE 4-10
SHALLOW GROUNDWATER - POSITIVE DETECTION SUMMARY
ENGINEERING PARAMETERS
SITE 1
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION	11GW11-01	1GW04-01	1GW04-01D	1GW05-01	1GW12-01	1GW13-01
DATE SAMPLED	02/10/96	02/10/96	02/10/96	02/10/96	02/09/96	02/10/96
ENGINEERING (mg/L)						
NITRATE NITRITE	0.1 U	0.78	0.79	0.1 U	0.12	0.95
TKN	0.8 U	1.2	1.3	1.3	2.1	2.1
TOTAL ORGANIC CARBON	1.5	4.2	4.4	5.5	10.5	2.4
TOC TEST 2	1.4	4.1	4.1	5.5	10.2	2.2
TOTAL DISSOLVED SOLIDS	36	400	400	220	320	53
TOTAL SUSPENDED SOLIDS	5 U	26	31	6	5 U	8

TABLE 4-10
SHALLOW GROUNDWATER - POSITIVE DETECTION SUMMARY
ENGINEERING PARAMETERS
SITE 1
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION	1GW14-01	1GW17-01	1GW18-01	1GW19-01	1GW20-01
DATE SAMPLED	02/08/96	02/08/96	02/09/96	02/09/96	02/10/96
ENGINEERING (mg/L)					
NITRATE NITRITE	0.1 U	12.6	3	1.4	0.68
TKN	0.8 U	0.8 U	5	0.8 U	0.8 U
TOTAL ORGANIC CARBON	2.2	2.4	16.2	6.2	5.4
TOC TEST 2	2.1	2.2	16.2	6.2	5.5
TOTAL DISSOLVED SOLIDS	50	120	190	360	120
TOTAL SUSPENDED SOLIDS	10	9	39	32	18

NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION	11GW11A-01	1GW12A-01	1GW12B-01	1GW13A-01	1GW13A-01D	1GW21-01
DATE SAMPLED	02/10/96	02/10/96	02/10/96	02/10/96	02/10/96	02/10/96
VOLATILES (ug/L)						
ACETONE	10 U	10 U	18	10 U	10 U	10 U
CHLOROFORM	10 U	10 U	10 U	10 U	10 U	3 J
TRICHLOROETHENE	10 U	46 B	360	10 U	10 U	2 J
SEMIVOLATILES (ug/L)						
PHENOL	10 U	10 U	130	10 U	10 U	10 U
PHENANTHRENE	10 U	10 U	10 U	2 J	2 J	10 U
PYRENE	10 U	10 U	10 U	2 J	10 U	10 U
DI-N-OCTYL PHTHALATE	10 U	10 U	10 U	4 J	10 U	10 U

TABLE 4-12
DEEP GROUNDWATER - POSITIVE DETECTION SUMMARY
INORGANICS
SITE 1
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION	11GW11A-01	1GW12A-01	1GW12B-01	1GW13A-01	1GW13A-01D	1GW21-01
DATE SAMPLED	02/10/96	02/10/96	02/10/96	02/10/96	02/10/96	02/10/96
TOTAL METALS (ug/L)						
ALUMINUM, TOTAL	287 B	165	10200	25900	18100	323
ARSENIC, TOTAL	0.9 U	1.6 L	4.2 L	24 L	18.1 L	0.9 U
BARIUM, TOTAL	11	25.2	66.8	105	81	15.9
BERYLLIUM, TOTAL	0.8 U	0.8 U	0.99	1.1	2.1	0.8 U
CADMIUM, TOTAL	2.2 U	2.2 U	2.2 U	3.3	2.4	2.2 U
CALCIUM, TOTAL	31300	39900	116000	138000	109000	87900
CHROMIUM, TOTAL	2.4 U	2.4 U	27.8	154	112	2.4 U
COBALT, TOTAL	3.9	3 U	3.4	12.6	9.6	4.1
COPPER, TOTAL	2 U	2 U	9.9	44.2	32.6	2 U
IRON, TOTAL	545	625	24200	73400	53600	730
LEAD, TOTAL	1.6	0.8 U	7.6 K	26.7	20.3	0.95
MAGNESIUM, TOTAL	447	535	3900	11600	8480	2520
MANGANESE, TOTAL	5.2 B	8.1	117	334	253	30.7
NICKEL, TOTAL	11.3 U	11.3 U	16.3	41.3	41.6	11.3 U
POTASSIUM, TOTAL	828 U	4570	26300	12800	10100	1120
SELENIUM, TOTAL	1.3 U	1.3 U	1.3 U	2.7	2.1	1.3 U
SODIUM, TOTAL	3510	8900	38300	5650	5810	6890
VANADIUM, TOTAL	2.6	2.4 U	28.2	104	75	3.9
ZINC, TOTAL	3.6 U	3.6 UL	44.4 L	156	117	3.6 U

TABLE 4-12
DEEP GROUNDWATER - POSITIVE DETECTION SUMMARY
DISSOLVED INORGANICS
SITE 1
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION	11GW11AF-01	1GW12AF-01	1GW12BF-01	1GW13AF-01	1GW13AF-01D	1GW21F-01
DATE SAMPLED	02/10/96	02/10/96	02/10/96	02/10/96	02/10/96	02/10/96
DISSOLVED INORGANICS (ug/L)						
ALUMINUM, SOLUBLE	23.3 U	23.3 U	1920	68.8	23.3 U	23.3 U
ARSENIC, SOLUBLE	0.9 U	0.9 UL	1.5 L	1.4 L	1.1 L	0.9 U
BARIUM, SOLUBLE	9.2	22.4	3.7	18.6	19.8	14.4
CALCIUM, SOLUBLE	27500	37600	11100	31400	31300	85600
COPPER, SOLUBLE	2 U	3.5	2 U	2 U	2 U	2 U
IRON, SOLUBLE	48 B	23.1	60.2	178	74.5	22 B
LEAD, SOLUBLE	0.86	0.8 U	0.8 U	0.8 U	0.8 U	2.4
MAGNESIUM, SOLUBLE	373	475	598	744	697	2440
MANGANESE, SOLUBLE	4.8 B	7	1.6 U	15.9	16.1	29.4
POTASSIUM, SOLUBLE	828 U	4520	24300	2210 L	2060 L	1300
SODIUM, SOLUBLE	3520	8620	37300	4480	4400	6950
VANADIUM, SOLUBLE	2.4 U	2.4 U	2.8	2.4 U	2.4 U	2.4 U

TABLE 4-13
DEEP GROUNDWATER - POSITIVE DETECTION SUMMARY
ENGINEERING PARAMETERS
SITE 1
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION	11GW11A-01	1GW12A-01	1GW12B-01	1GW13A-01	1GW13A-01D	1GW21-01
DATE SAMPLED	02/10/96	02/10/96	02/10/96	02/10/96	02/10/96	02/10/96
ENGINEERING (mg/L)						
NITRATE NITRITE	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
TKN	0.8 U	0.9	1.8	3.9	3.9	0.92
TOTAL ORGANIC CARBON	1.6	2.1	4.8	2.6	2.6	1.5
TOC TEST 2	1.1	2.1	4.7	2.5	2.4	1.5
TOTAL DISSOLVED SOLIDS	100	130	340	420	360	290
TOTAL SUSPENDED SOLIDS	13	40	890	1400	440	16

TABLE 4-14
SURFACE WATER - POSITIVE DETECTION SUMMARY
INORGANICS
SITE 1
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION	1SW15	1SW16	1SW16D	1SW17
DATE SAMPLED	09/08/95	09/09/95	09/09/95	09/08/95
TOTAL METALS (ug/L)				
ALUMINUM, TOTAL	1110	1800	1380	2420
BARIUM, TOTAL	31	31.4	32	32
CADMIUM, TOTAL	8.9 L	7.8 L	9.1 L	9 L
CALCIUM, TOTAL	242000 J	194000 J	198000 J	249000 J
COPPER, TOTAL	9.1 K	7.4 K	8 K	7.7 K
IRON, TOTAL	1220 J	1900 J	1760 J	3250 J
LEAD, TOTAL	1.4 UL	1.8 L	2.4 L	14 UL
MAGNESIUM, TOTAL	769000	598000	616000	786000
MANGANESE, TOTAL	20.8	53.3 J	54.9 J	47.4 J
POTASSIUM, TOTAL	245000	193000	198000	249000
SODIUM, TOTAL	5870000	4680000	4800000	6040000
VANADIUM, TOTAL	9.7	10.8	10	13.4
ZINC, TOTAL	10.4 K	15 K	15.2 K	20.1 K

TABLE 4-14
SURFACE WATER - POSITIVE DETECTION SUMMARY
DISSOLVED INORGANICS
SITES 1 AND 3 (1)
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION	1SW15F	1SW16F	1SW16DF	1SW17F
DATE SAMPLED	09/08/95	09/09/95	09/09/95	09/08/95
DISSOLVED INORGANICS (ug/L)				
ALUMINUM, SOLUBLE	33.2	16.9 U	17.2	38.3
BARIUM, SOLUBLE	22.5	26	25.7	21.9
CADMIUM, SOLUBLE	4.8 L	3.7 UL	5.8 L	8.5 L
CALCIUM, SOLUBLE	245000 J	193000 J	198000 J	250000 J
COPPER, SOLUBLE	6.5 K	10.2 K	22.3 K	5.5 K
IRON, SOLUBLE	18.2 J	15.7 J	10.3 J	6.3 J
LEAD, SOLUBLE	7 UL	2.6 L	1.4 UL	7 UL
MAGNESIUM, SOLUBLE	772000	597000	611000	790000
MANGANESE, SOLUBLE	7.6 J	29.8 J	27 J	0.7 U
POTASSIUM, SOLUBLE	245000	192000	197000	250000
SODIUM, SOLUBLE	5990000	4710000	5020000	6110000
VANADIUM, SOLUBLE	7.4	5.5	7.3	8.7
ZINC, SOLUBLE	6.5 K	8.5 K	15.7 K	7.4 K

(1) Due to tide influence, all samples collected within Indian Field Creek are associated with both sites 1 and 3 (although labeled as site 1).

TABLE 4-15
SURFACE WATER - POSITIVE DETECTION SUMMARY
ENGINEERING PARAMETERS
SITE 1
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION	1SW15	1SW16	1SW16D	1SW17
DATE SAMPLED	09/08/95	09/09/95	09/09/95	09/08/95
ENGINEERING (mg/L)				
HARDNESS BY EDTA	4130	3220	3140	4120
TOTAL ORGANIC CARBON	41.9	10.7	11.9	11.6
TOC TEST 2	32.3	10.2	10.9	11.3

TABLE 4-16
SEDIMENT - POSITIVE DETECTION SUMMARY
ORGANIC COMPOUNDS
SITES 1 AND 3 (1)
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION	1SD13-01	1SD13-02	1SD14-01	1SD14-02	1SD15-01	1SD15-02
DATE SAMPLED	09/09/95	09/09/95	09/08/95	09/08/95	09/08/95	09/08/95
DEPTH	0-4"	4-8"	0-4"	4-8"	0-4"	4-8"
VOLATILES (ug/kg)						
ACETONE	12 U	11 U	120	99	35 U	230
CARBON DISULFIDE	12 U	11 U	12 U	12 U	10 J	29
TOLUENE	12 U	2 J	12 U	12 U	35 U	26 UJ

(1) Due to tide influence, all samples collected within Indian Field Creek are associated with both sites 1 and 3 (although labeled as site 1).

ORGANIC COMPOUNDS
SITES 1 AND 3 (1)
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION	1SD16-01	1SD16-01D	1SD16-02	1SD17-01
DATE SAMPLED	09/09/95	09/09/95	09/09/95	09/08/95
DEPTH	0-4"	0-4"	4-8"	0-4"
VOLATILES (ug/kg)				
ACETONE	180 B	44 B	66	42 U
CARBON DISULFIDE	30 UJ	31 UJ	14 J	42 U
TOLUENE	30 UJ	31 UJ	25 U	42 U

(1) Due to tide influence, all samples collected within Indian Field Creek are associated with both sites 1 and 3 (although labeled as site 1).

TABLE 4-17
SEDIMENT - POSITIVE DETECTION SUMMARY
INORGANICS
SITES 1 AND 3 (1)
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION	1SD13-01	1SD13-02	1SD14-01	1SD14-02	1SD15-01	1SD15-02
DATE SAMPLED	09/09/95	09/09/95	09/08/95	09/08/95	09/08/95	09/08/95
DEPTH	0-4"	4-8"	0-4"	4-8"	0-4"	4-8"
INORGANICS (mg/kg)						
ALUMINUM	1760	1240	434	659	15500	21100
ARSENIC	1.5	0.63	0.37 U	0.3 U	8	12.6
BARIUM	25.7 J	16.6 J	1.9 J	3.9 J	46.1 J	37.6 J
CADMIUM	0.68 U	0.72 U	0.69 U	0.76 U	2.2 U	1.7 U
CALCIUM	716 J	341 J	1540 J	39000 J	129000 J	3420 J
CHROMIUM	2.2	1.1	0.7 U	1.5	32.2	42.2
COBALT	0.88 B	0.43 U	0.46	0.45 U	6.2	8
COPPER	4.2	2.9	0.82	0.96	20.2	14
IRON	4280	1320	577	1350	31400	37200
LEAD	7.4	8.5	0.91	1.4	56.8	14
MAGNESIUM	94.2	60.8	109	525	7680	6590
MANGANESE	66.1	9.1	3.7	11.6	262	379
NICKEL	2.1 U	2.3 U	2.1 U	2.4 U	11.8	17.3
POTASSIUM	97.9 U	104 U	98.9 U	141	3680	4010
SODIUM	24.5 B	16 B	318	559	13600	5820
VANADIUM	4.3	2.3	0.79	1.8	38.6	47.7
ZINC	16.3	7.7	3.1	4.8	99.8	72.1

(1) Due to tide influence, all samples collected within Indian Field Creek are associated with both sites 1 and 3 (although labeled as site 1).

TABLE 4-17
SEDIMENT - POSITIVE DETECTION SUMMARY
INORGANICS
SITES 1 AND 3 (1)
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION	1SD16-01	1SD16-01D	1SD16-02	1SD17-01
DATE SAMPLED	09/09/95	09/09/95	09/09/95	09/08/95
DEPTH	0-4"	0-4"	4-8"	0-4"
INORGANICS (mg/kg)				
ALUMINUM	17400	14500	15900	20500
ARSENIC	9.5	15.4	12.7	8.1
BARIUM	33.5 J	30.3 J	31.4 J	39.9 J
CADMIUM	2.1 U	2.3 U	1.7	2.4 U
CALCIUM	2450 J	2350 J	2250 J	2920 J
CHROMIUM	39.7	36	36.3	45.8
COBALT	7.1	8	6.9	8.9
COPPER	26.1	26.7	23.7	26.4
IRON	39100	38200	36600	38100
LEAD	25.6	29.2	28.8	26.2
MAGNESIUM	7730	7380	6850	9050
MANGANESE	238	228	228	286
NICKEL	18.4	17.5	17.5	21
POTASSIUM	3850	3740	3550	5090
SODIUM	13800	14400	9860	21100
VANADIUM	46.8	43.8	46.9	51.8
ZINC	128	120	112	135

(1) Due to tide influence, all samples collected within Indian Field Creek are associated with both sites 1 and 3 (although labeled as site 1).

TABLE 4-18
SEDIMENT - POSITIVE DETECTION SUMMARY
ENGINEERING PARAMETERS
SITE 1
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION	1SD13-01	1SD13-02	1SD14-01	1SD14-02	1SD15-01	1SD15-02
DATE SAMPLED	09/09/95	09/09/95	09/08/95	09/08/95	09/08/95	09/08/95
DEPTH	0-4"	4-8"	0-4"	4-8"	0-4"	4-8"
ENGINEERING						
% SOLIDS	86.6	91.3	85	84.1	28.3	39.1
TOTAL ORGANIC CARBON %	1.3	0.51	0.22	0.14	5	4.4
PH	6.3	6.3	7.8	7.3	7.4	7.7

TABLE 4-18
SEDIMENT - POSITIVE DETECTION SUMMARY
ENGINEERING PARAMETERS
SITE 1
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION	1SD16-01	1SD16-01D	1SD16-02	1SD17-01
DATE SAMPLED	09/09/95	09/09/95	09/09/95	09/08/95
DEPTH	0-4"	0-4"	4-8"	0-4"
ENGINEERING				
% SOLIDS	33.3	31.8	39.4	23.6
TOTAL ORGANIC CARBON %	5	4.5	3.7	7.2
PH	7.8	7.7	7.8	7

TABLE 4-19
SURFACE SOIL - POSITIVE DETECTION SUMMARY
ORGANIC COMPOUNDS
SITE 3
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION	3SB08A-00	3SB15A-00	3SB19A-00	3SS04	3SS04D	3SS05	3SS06	3SS07
DATE SAMPLED	02/08/96	01/29/96	01/30/96	01/26/96	01/26/96	01/26/96	01/26/96	01/27/96
DEPTH	0-0.5'	0-0.5'	0-0.5'	0-0.5'	0-0.5'	0-0.5'	0-0.5'	0-0.5'
SEMIVOLATILES (ug/kg)								
NAPHTHALENE	400 U	360 U	390 U	380 U	390 U	430 U	440 U	380 U
2-METHYLNAPHTHALENE	400 U	360 U	390 U	380 U	390 U	430 U	440 U	380 U
ACENAPHTHYLENE	400 U	360 U	390 U	380 U	390 U	430 U	440 U	380 U
ACENAPHTHENE	400 U	360 U	390 U	380 U	390 U	430 U	440 U	380 U
DIBENZOFURAN	400 U	360 U	390 U	380 U	390 U	430 U	440 U	380 U
FLUORENE	400 U	360 U	390 U	380 U	390 U	430 U	440 U	380 U
PHENANTHRENE	220 J	360 U	390 U	380 U	390 U	430 U	440 U	380 U
ANTHRACENE	400 U	360 U	390 U	380 U	390 U	430 U	440 U	380 U
CARBAZOLE	400 U	360 U	390 U	380 U	390 U	430 U	440 U	380 U
FLUORANTHENE	140 J	360 U	390 U	380 U	390 U	430 U	440 U	380 U
PYRENE	240 J	360 U	390 U	380 U	390 U	430 U	440 U	380 U
BENZO(A)ANTHRACENE	120 J	360 U	390 U	380 U	390 U	430 U	440 U	380 U
CHRYSENE	170 J	360 U	390 U	380 U	390 U	430 U	440 U	380 U
BIS(2-ETHYLHEXYL)PHTHALATE	200 B	40 B	58 B	380 U	390 U	51 B	440 U	41 B
BENZO(B)FLUORANTHENE	220 J	360 U	390 U	380 U	390 U	430 U	440 U	380 U
BENZO(K)FLUORANTHENE	400 U	360 U	390 U	380 U	390 U	430 U	440 U	380 U
BENZO(A)PYRENE	160 J	360 U	390 U	380 U	390 U	430 U	440 U	380 U
INDENO(1,2,3-CD)PYRENE	400 U	360 U	390 U	380 U	390 U	430 U	440 U	380 U
DIBENZO(A,H)ANTHRACENE	400 U	360 U	390 U	380 U	390 U	430 U	440 U	380 U
BENZO(G,H,I)PERYLENE	87 J	360 U	390 U	380 U	390 U	430 U	440 U	380 U
PESTICIDE/PCBS (ug/kg)								
DIELDRIN	4 U	3.6 U	4 U	3.8 U	3.9 U	4.3 U	4.4 U	3.8 U
4,4'-DDE	8.5 J	3.6 U	4 U	3.8 U	3.9 U	4.3 U	4.4 U	3.8 U
4,4'-DDD	2.4 J	3.6 U	4 U	3.8 U	3.9 U	4.3 U	4.4 U	3.8 U
ENDOSULFAN SULFATE	4 U	3.6 U	4 U	3.8 U	3.9 U	4.3 U	4.4 U	3.8 U
4,4'-DDT	8.9 J	3.6 U	4 U	3.8 U	3.9 U	4.3 U	4.4 U	3.8 U
METHOXYCHLOR	20 U	18 U	20 U	19 U	19 U	22 U	22 U	19 U
ENDRIN KETONE	4 U	3.6 U	4 U	3.8 U	3.9 U	4.3 U	4.4 U	3.8 U
AROCLOR-1260	40 U	36 U	40 U	38 U	39 U	43 U	44 U	38 U

TABLE 4-19
SURFACE SOIL - POSITIVE DETECTION SUMMARY
ORGANIC COMPOUNDS
SITE 3
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION	3SS08	3SS09	3SS11	3SS11D	3SS12	3SS13	3SS14	3SS10
DATE SAMPLED	01/26/96	01/26/96	01/30/96	01/30/96	01/27/96	01/27/96	01/30/96	01/27/96
DEPTH	0-0.5'	0-0.5'	0-0.5'	0-0.5'	0-0.5'	0-0.5'	0-0.5'	0-0.5'
SEMIVOLATILES (ug/kg)								
NAPHTHALENE	420 U	380 U	370 U	380 U	440 U	410 U	380 U	7300 J
2-METHYLNAPHTHALENE	420 U	380 U	370 U	380 U	440 U	410 U	380 U	4000 J
ACENAPHTHYLENE	420 U	380 U	370 U	380 U	440 U	410 U	380 U	8100 U
ACENAPHTHENE	420 U	380 U	370 U	380 U	440 U	410 U	380 U	18000
DIBENZOFURAN	420 U	380 U	370 U	380 U	440 U	410 U	380 U	14000
FLUORENE	420 U	380 U	370 U	380 U	440 U	410 U	380 U	22000
PHENANTHRENE	420 U	380 U	370 U	380 U	440 U	410 U	380 U	200000
ANTHRACENE	420 U	380 U	370 U	380 U	440 U	410 U	380 U	47000
CARBAZOLE	420 U	380 U	370 U	380 U	440 U	410 U	380 U	37000
FLUORANTHENE	420 U	380 U	370 U	380 U	440 U	410 U	380 U	190000
PYRENE	420 U	380 U	370 U	380 U	440 U	410 U	380 U	160000
BENZO(A)ANTHRACENE	420 U	380 U	370 U	380 U	440 U	410 U	380 U	92000
CHRYSENE	420 U	380 U	370 U	380 U	440 U	410 U	380 U	87000
BIS(2-ETHYLHEXYL)PHTHALATE	420 U	380 U	370 U	48 B	64 B	46 B	380 U	8100 U
BENZO(B)FLUORANTHENE	420 U	380 U	370 U	380 U	440 U	410 U	380 U	98000
BENZO(K)FLUORANTHENE	420 U	380 U	370 U	380 U	440 U	410 U	380 U	32000
BENZO(A)PYRENE	420 U	380 U	370 U	380 U	440 U	410 U	380 U	77000
INDENO(1,2,3-CD)PYRENE	420 U	380 U	370 U	380 U	440 U	410 U	380 U	47000
DIBENZO(A,H)ANTHRACENE	420 U	380 U	370 U	380 U	440 U	410 U	380 U	12000
BENZO(G,H,I)PERYLENE	420 U	380 U	370 U	380 U	440 U	410 U	380 U	41000
PESTICIDE/PCBS (ug/kg)								
DIELDRIN	4.2 U	3.8 U	3.7 U	3.8 U	4.5 U	4.1 U	3.8 U	4.4 L
4,4'-DDE	4.2 U	3.8 U	3.7 U	3.8 U	4.5 U	4.1 U	3.8 U	4 UL
4,4'-DDD	4.2 U	3.8 U	3.7 U	3.8 U	4.5 U	4.1 U	3.8 U	4 UL
ENDOSULFAN SULFATE	4.2 U	3.8 U	3.7 U	3.8 U	4.5 U	4.1 U	3.8 U	5.3 J
4,4'-DDT	4.2 U	3.8 U	3.7 U	3.8 U	4.5 U	4.1 U	3.8 U	4 UL
METHOXYCHLOR	21 U	19 U	18 U	19 U	22 U	20 U	19 U	62 J

TABLE 4-19
SURFACE SOIL - POSITIVE DETECTION SUMMARY
ORGANIC COMPOUNDS
SITE 3
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION	3SS10A	3SS10C	3SS10D	3SS10E	3SS10F
DATE SAMPLED	07/26/96	07/26/96	07/26/96	07/26/96	07/26/96
DEPTH	0-0.5"	0-0.5'	0-0.5'	0-0.5'	0-0.5'
SEMIVOLATILES (ug/kg)					
NAPHTHALENE	86 J	700	390 U	410 U	62 J
2-METHYLNAPHTHALENE	57 J	400 J	390 U	410 U	400 U
ACENAPHTHYLENE	380 U	60 J	390 U	410 U	400 U
ACENAPHTHENE	440	2800	390 U	410 U	260 J
DIBENZOFURAN	310 J	2100	390 U	410 U	190 J
FLUORENE	490	3000	390 U	410 U	290 J
PHENANTHRENE	6600	49000	310 J	250 J	3400
ANTHRACENE	1500	15000	65 J	87 J	810
CARBAZOLE	1200	9500	63 J	43 J	720
FLUORANTHENE	8300	56000	390 J	370 J	4200
PYRENE	7000	49000	340 J	290 J	3400
BENZO(A)ANTHRACENE	3600	28000	190 J	160 J	2100
CHRYSENE	4600	33000	230 J	230 J	2200
BIS(2-ETHYLHEXYL)PHTHALATE	380 U	47000	84 J	48 J	49 J
BENZO(B)FLUORANTHENE	5300	38000	270 J	120 J	2400
BENZO(K)FLUORANTHENE	1700	5400 J	130 J	200 J	1100
BENZO(A)PYRENE	4000	31000	230 J	170 J	1900
INDENO(1,2,3-CD)PYRENE	1800	18000	160 J	120 J	1400
DIBENZO(A,H)ANTHRACENE	280 J	2300	41 J	410 U	270 J
BENZO(G,H,I)PERYLENE	1400	18000	110 J	110 J	970
PESTICIDE/PCBS (ug/kg)					
DIELDRIN	NA	NA	NA	NA	NA
4,4'-DDE	NA	NA	NA	NA	NA
4,4'-DDD	NA	NA	NA	NA	NA
ENDOSULFAN SULFATE	NA	NA	NA	NA	NA
4,4'-DDT	NA	NA	NA	NA	NA
METHOXYCHLOR	NA	NA	NA	NA	NA
ENDRIN KETONE	NA	NA	NA	NA	NA
AROCLOR-1260	NA	NA	NA	NA	NA

TABLE 4-20
SURFACE SOIL - POSITIVE DETECTION SUMMARY
INORGANICS
SITE 3
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

DATE SAMPLED	02/08/96	01/29/96	01/30/96	01/26/96	01/26/96	01/26/96
DEPTH	0-0.5'	0-0.5'	0-0.5'	0-0.5'	0-0.5'	0-0.5'
INORGANICS (mg/kg)						
ALUMINUM	4290	985	2870	3520	3370	8880
ANTIMONY	4.4 UL	3.1 UL	4.5 UL	3.7 UL	3.9 UL	4.3 UL
ARSENIC	5 L	1.8	1.5	1.2	1.5	4.7
BARIUM	35.7	3.7	19.4	26.1	25.1	38.5
BERYLLIUM	0.58 K	0.2	0.44	0.39	0.38	0.67
CADMIUM	0.55 L	0.34 U	0.5 U	0.41 U	0.43 U	0.47 U
CALCIUM	1860 J	65.8 B	511	426	676	1440
CHROMIUM	18.7	3.1 K	3 K	4	4.1	22.1
COBALT	4.3	0.55	1.6	1.5	1.2	3.5
COPPER	12.9	0.67	2.4	1.7	1.9	4.4
IRON	23800	2530	2460	3440	3710	16200
LEAD	74.3	3.1	8.1	6.5	7.4	10.9
MAGNESIUM	509	123	202	297	287	898
MANGANESE	244	6.7	30.5	109	112	69.9
MERCURY	0.11	0.04 U	0.06 U	0.05 U	0.04 U	0.05 U
NICKEL	8.9	1.8 U	2.7 K	2.6 K	2.2 U	7.9 K
POTASSIUM	382 L	203 L	190 UL	232 K	232 K	1050 K
SELENIUM	0.33 L	0.23 U	0.27 U	0.24 U	0.25 U	0.26 U
SODIUM	24.4 B	4.5	14.5	6.8	5.5	13
THALLIUM	0.16 UL	0.16 U	0.19 U	0.31 U	0.32 U	0.34 U
VANADIUM	36.4	5.3	7.5	7.4	7.7	32.8
ZINC	203	3.7 L	11.5	11.1 B	10.5 B	23.9
CYANIDE	0.48 UL	0.45 U	0.48 U	0.52 U	0.5 U	0.6 U

TABLE 4-20
SURFACE SOIL - POSITIVE DETECTION SUMMARY
INORGANICS
SITE 3
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION	3SS06	3SS07	3SS08	3SS09	3SS10	3SS11
DATE SAMPLED	01/26/96	01/27/96	01/26/96	01/26/96	01/27/96	01/30/96
DEPTH	0-0.5'	0-0.5'	0-0.5'	0-0.5'	0-0.5'	0-0.5'
INORGANICS (mg/kg)						
ALUMINUM	4200	3880	5770	4120	10100	2330
ANTIMONY	4.3 UL	4.4 UL	4.9 UL	3.5 UL	4.6 UL	4.6 L
ARSENIC	2.1	1.9	1.2	3.6	9.5	1.9
BARIUM	36.8	21.7	82.6	20.9	164	10.7
BERYLLIUM	0.44	0.18 U	1.5	0.36	0.98	0.35
CADMIUM	0.48 U	0.49 U	0.55 U	0.39 U	0.74 K	0.4 U
CALCIUM	2710	786	1640	563	24000	355
CHROMIUM	13.2	8.2	4.2	8.7	16	5.4 K
COBALT	5	1.5	6	1.8	1.2	1.1
COPPER	3.7	2.9	3.6	2.4	10.9	4.2
IRON	11400	5190	3040	7700	8040	3350
LEAD	6.5	7.5	14.4	8.3	59.4	28.1
MAGNESIUM	883	353	377	369	5350	198
MANGANESE	117	115	667	96	1580	41.6
MERCURY	0.05 U	0.06 U	0.05 U	0.04 U	0.15	0.05
NICKEL	5.5 K	3.1 K	7.7 K	2 K	21.5	2.3 K
SODIUM	11.4	5.8	5.7	8.4	252	6.1
THALLIUM	0.35 U	0.3 U	0.35 U	0.32 U	0.34 U	0.17 U

TABLE 4-20
SURFACE SOIL - POSITIVE DETECTION SUMMARY
INORGANICS
SITE 3
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION	3SS11D	3SS12	3SS13	3SS14
DATE SAMPLED	01/30/96	01/27/96	01/27/96	01/30/96
DEPTH	0-0.5'	0-0.5'	0-0.5'	0-0.5'
INORGANICS (mg/kg)				
ALUMINUM	2200	11800	7620	2370
ANTIMONY	16.8 L	5.2 UL	3.5 UL	3.6 UL
ARSENIC	1.7	5.2	6.9	1.4
BARIUM	10.6	20.4	32.9	26.8
BERYLLIUM	0.38	0.53	0.46	0.57
CADMIUM	0.44 U	0.58 U	0.39 U	0.4 U
CALCIUM	305 B	321	441	546
CHROMIUM	5.5 K	31.6 K	20.7 K	2.9 K
COBALT	1	1.9	2.3	2.7
COPPER	3.6	7.7	4.6	1.8
IRON	3150	19700	16800	2500
LEAD	30.6	14.7	12.4	6.9
MAGNESIUM	190	1050	612	184
MANGANESE	41.1	17.9	48.6	103
MERCURY	0.05 U	0.05 U	0.04 U	0.05 U
NICKEL	2.2 U	3 U	5.2 K	2.4 K
POTASSIUM	193 L	1500 L	742 L	200 L
SELENIUM	0.29 U	0.31	0.31	0.22
SODIUM	9.6 UL	29.1	16.3	8.9
THALLIUM	0.2 U	0.2 U	0.23 K	0.15 U
VANADIUM	7.2	37.7	31.7	5.3
ZINC	22	21.9	51.3	10.8
CYANIDE	0.45 U	0.56 U	0.51 U	0.48 U

TABLE 4-21
SUBSURFACE SOIL - POSITIVE DETECTION SUMMARY
ORGANIC COMPOUNDS
SITE 3
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION	3SB019A-07	3SB019A-14	3SB08A-04	3SB08A-09	3SB08AD-04	3SB10B-01	3SB15A-08
DATE SAMPLED	02/07/96	02/07/96	02/08/96	02/08/96	02/08/96	07/26/96	01/29/96
DEPTH	13-15'	27-29'	7-9'	17-19'	7-9'		15-17'
VOLATILES (ug/kg)							
METHYLENE CHLORIDE	12 U	12 U	14 U	12 U	13 U	NA	15 U
ACETONE	12 UJ	12 UJ	14 UJ	12 UJ	13 UJ	NA	26 B
1,2-DICHLOROETHENE (TOTAL)	12 U	12 U	14 U	12 U	13 U	NA	19
2-BUTANONE	12 U	12 U	14 U	12 U	13 U	NA	15 U
TRICHLOROETHENE	12 U	12 U	14 U	12 U	13 U	NA	10 J
ETHYLBENZENE	12 U	12 U	14 U	12 U	13 U	NA	15 UJ
SEMIVOLATILES (ug/kg)							
4-METHYLPHENOL	410 U	400 U	440 U	400 U	430 U	370 U	510 U
2-METHYLNAPHTHALENE	410 U	400 U	440 U	400 U	430 U	370 U	510 U
ACENAPHTHENE	410 U	400 U	440 U	400 U	430 U	39 J	510 U
FLUORENE	410 U	400 U	440 U	400 U	430 U	40 J	510 U
PENTACHLOROPHENOL	1000 U	1000 U	1100 U	990 U	1100 U	41 J	1300 U
PHENANTHRENE	410 U	400 U	440 U	400 U	430 U	530	510 U
ANTHRACENE	410 U	400 U	440 U	400 U	430 U	120 J	510 U
CARBAZOLE	410 U	400 U	440 U	400 U	430 U	98 J	510 U
FLUORANTHENE	410 U	400 U	440 U	400 U	430 U	610	510 U
PYRENE	410 U	400 U	440 U	400 U	430 U	420	510 U
BENZO(A)ANTHRACENE	410 U	400 U	440 U	400 U	430 U	230 J	510 U
CHRYSENE	410 U	400 U	440 U	400 U	430 U	270 J	510 U
BIS(2-ETHYLHEXYL)PHTHALATE	120 B	400 U	94 B	43 B	430 U	95 J	120 B
DI-N-OCTYL PHTHALATE	410 U	400 U	440 U	400 U	430 U	370 U	510 U
BENZO(B)FLUORANTHENE	410 U	400 U	440 U	400 U	430 U	390	510 U
BENZO(K)FLUORANTHENE	410 U	400 U	440 U	400 U	430 U	110 J	510 U
BENZO(A)PYRENE	410 U	400 U	440 U	400 U	430 U	260 J	510 U
INDENO(1,2,3-CD)PYRENE	410 U	400 U	440 U	400 U	430 U	170 J	510 U
BENZO(G,H,I)PERYLENE	410 U	400 U	440 U	400 U	430 U	150 J	510 U
PESTICIDE/PCBS (ug/kg)							
BETA-BHC	2.1 U	2 U	2.2 U	2 U	2.1 U	NA	2.6 U
DELTA-BHC	2.1 U	2 U	2.2 U	2 U	2.1 U	NA	2.6 U
4,4'-DDE	4.1 U	4 U	4.5 U	3.9 U	4.2 U	NA	5.1 U
ENDRIN	4.1 U	4 U	4.5 U	3.9 U	4.2 U	NA	5.1 U
ENDOSULFAN II	4.1 U	4 U	4.5 U	3.9 U	4.2 U	NA	5.1 U
4,4'-DDD	4.1 U	4 U	4.5 U	3.9 U	4.2 U	NA	5.1 U
4,4'-DDT	4.1 U	4 U	4.5 U	3.9 U	4.2 U	NA	5.1 U

TABLE 4-21
SUBSURFACE SOIL - POSITIVE DETECTION SUMMARY
ORGANIC COMPOUNDS
SITE 3
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION	3SB15A-12	3TP01	3TP02	3TP02D	3TP03	3TP04
DATE SAMPLED	01/29/96	01/26/96	01/26/96	01/26/96	01/26/96	01/26/96
DEPTH	23-25'	3-4'	8-9'	8-9'	3-4'	3-4'
VOLATILES (ug/kg)						
METHYLENE CHLORIDE	13 U	14 U	15	13 U	13 U	10 U
ACETONE	36 B	17 J	930 J	770 J	22 J	10 U
1,2-DICHLOROETHENE (TOTAL)	13 U	14 U	160	200	13 U	10 U
2-BUTANONE	13 U	14 U	160	110	13 U	10 U
TRICHLOROETHENE	13 U	14 U	13 U	13 U	13 U	10 U
ETHYLBENZENE	13 U	14 U	6 J	2 J	13 U	10 U
SEMIVOLATILES (ug/kg)						
4-METHYLPHENOL	420 U	480 U	250 J	210 J	430 U	350 U
2-METHYLNAPHTHALENE	180 J	480 U	380 J	150 J	430 U	350 U
ACENAPHTHENE	420 U	480 U	420 U	420 U	430 U	350 U
FLUORENE	360 J	480 U	67 J	420 U	430 U	350 U
PENTACHLOROPHENOL	1000 U	1200 U	1000 U	1000 U	1100 U	880 U
PHENANTHRENE	1400	480 U	160 J	110 J	430 U	350 U
ANTHRACENE	420 U	480 U	420 U	420 U	430 U	350 U
CARBAZOLE	420 U	480 U	420 U	420 U	430 U	350 U
FLUORANTHENE	420 U	480 U	420 U	420 U	430 U	350 U
PYRENE	140 J	480 U	420 U	420 U	430 U	350 U
BENZO(A)ANTHRACENE	420 U	480 U	420 U	420 U	430 U	350 U
CHRYSENE	44 J	480 U	420 U	420 U	430 U	350 U
BIS(2-ETHYLHEXYL)PHTHALATE	83 B	480 U	85 J	60 J	430 U	350 U
DI-N-OCTYL PHTHALATE	420 U	480 U	420 U	420 U	430 U	350 U
BENZO(B)FLUORANTHENE	420 U	480 U	420 U	420 U	430 U	350 U
BENZO(K)FLUORANTHENE	420 U	480 U	420 U	420 U	430 U	350 U
BENZO(A)PYRENE	420 U	480 U	420 U	420 U	430 U	350 U
INDENO(1,2,3-CD)PYRENE	420 U	480 U	420 U	420 U	430 U	350 U
BENZO(G,H,I)PERYLENE	420 U	480 U	420 U	420 U	430 U	350 U
PESTICIDE/PCBS (ug/kg)						
BETA-BHC	1.7 J	2.3 UJ	2.1 UJ	2.1 UJ	2.2 UJ	1.8 UJ
DELTA-BHC	1.7 J	2.3 UJ	2.1 UJ	2.1 UJ	2.2 UJ	1.8 UJ
4,4'-DDE	3.8 J	4.7 UJ	4.2 UJ	4.6 J	4.3 UJ	3.5 UJ
ENDRIN	4.2	4.7 UJ	4.2 UJ	4.2 UJ	4.3 UJ	3.5 UJ
ENDOSULFAN II	5	4.7 UJ	4.2 UJ	4.2 UJ	4.3 UJ	3.5 UJ
4,4'-DDD	4.2 U	4.7 UJ	4.2 UJ	4.2 J	4.3 UJ	3.5 UJ
4,4'-DDT	3.4 J	4.7 UJ	4.2 UJ	4.2 UJ	4.3 UJ	3.5 UJ

TABLE 4-22
SUBSURFACE SOIL - POSITIVE DETECTION SUMMARY
INORGANICS
SITE 3
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION	3SB019A-07	3SB019A-14	3SB08A-04	3SB08A-09	3SB08AD-04	3SB15A-08
DATE SAMPLED	02/07/96	02/07/96	02/08/96	02/08/96	02/08/96	01/29/96
DEPTH	13-15'	27-29'	7-9'	17-19'	7-9'	15-17'
INORGANICS (mg/kg)						
ALUMINUM	9780	4620	10300	5410	15100	9670
ANTIMONY	4.2 UL	4.7 UL	5.2 UL	4.3 UL	4.5 UL	4.3 UL
ARSENIC	38.1 L	3.1 L	13.2 L	2.4 L	4 L	10.3 J
BARIUM	15	22.2	44.5	17.3	54.3	42.3
BERYLLIUM	0.17 U	0.31 K	1.5 K	0.49 K	2.3	0.58
CADMIUM	0.47 UL	0.52 UL	0.58 UL	0.48 UL	0.51 UL	0.47 U
CALCIUM	145 J	184000 J	3100 J	93300 J	3420 J	475
CHROMIUM	32.1	17.3	36.3	20.5	65	25.6 K
COBALT	0.63 U	2.3	18.2	2.4	39.4	3.1
COPPER	7.1	3.7	10	3.5	12	7.6
IRON	42900	13000	34600	17600	72700	15600
LEAD	21.5	3.3	13.3	3.6	11.7	16.6 J
MAGNESIUM	555	2510	2110	2290	2310	1740
MANGANESE	6.8	170	95.7	90.1	269	24.9
MERCURY	0.05 U	0.05 U	0.05 U	0.05 U	0.04 U	0.06 U
NICKEL	3	6.5	17.2	6	31	7.2
POTASSIUM	923 L	1820 L	1730 L	2620	1940 L	2110
SELENIUM	1.5 L	0.24 UL	0.26 UL	0.57 L	0.26 UL	0.3 U
SILVER	0.66 U	0.73 U	0.82 U	0.67 U	0.71 U	0.67 U
SODIUM	52.7 B	1220	219	859	229	40.7
VANADIUM	71	14.3	34.8	17.2	84	15.3
ZINC	7.5 L	18.2	56.4	22.4	80	44.5 J

TABLE 4-22
SUBSURFACE SOIL - POSITIVE DETECTION SUMMARY
INORGANICS
SITE 3
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION	3SB15A-12	3TP01	3TP02	3TP02D	3TP03	3TP04
DATE SAMPLED	01/29/96	01/26/96	01/26/96	01/26/96	01/26/96	01/26/96
DEPTH	23-25'	3-4'	8-9'	8-9'	3-4'	3-4'
INORGANICS (mg/kg)						
ALUMINUM	4540	13000	9740	9910	14500	2680
ANTIMONY	5.4 L	4.9 UL	3.9 UL	3.8 UL	4.5 UL	3.7 UL
ARSENIC	6.1 J	6.1 L	7.8 L	8.5 L	1.3 L	0.67 L
BARIUM	25.3	17.1	42.5	53.7	22.8	13.5
BERYLLIUM	0.59	0.56	2.1	3.9	0.23	0.17
CADMIUM	0.46	0.55 U	0.44 U	0.42 U	0.5 U	0.41 U
CALCIUM	225000	548	1330	1640	785	108
CHROMIUM	14.9 K	41.1 K	34.6 K	36.4 K	32.5 K	3.5 K
COBALT	2.2	6.8	16.8	25.6	0.68 U	2
COPPER	3.7	6.6	7.8	8.6	6.4	1.3
IRON	12300	40600	29400	33500	13200	3330
LEAD	5 J	10.6 L	15.2 L	16.6 L	10.1 L	1.7 L
MAGNESIUM	2890	2010	2700	2590	1120	205
MANGANESE	136	83.1	76.7	110	17.8	47.1
MERCURY	0.05 U	0.07 U	0.06 U	0.1	0.06 U	0.04 U
NICKEL	7.2	10.1	21.8	31.6	2.6 U	2.8
POTASSIUM	1480 L	2700	3280	3010	1540 K	156 U
SELENIUM	0.27 U	0.34 U	0.23 U	0.29 U	0.33 U	0.24 U
SILVER	0.56 U	0.93	0.61 U	0.59 U	0.7 U	0.58 U
SODIUM	1330	21	21.8	25.4	48.9	5.5
VANADIUM	12.9	42.5	24.9	25.6	25.1	4.8
ZINC	16.9 J	42.4	79.2	92.4	12.5 B	5.3 K

LOCATION DATE SAMPLED DEPTH	MINIMUM NONDETECTED	MAXIMUM NONDETECTED	MINIMUM DETECTED	MAXIMUM DETECTED	LOCATION OF MAXIMUM DETECTED	FREQUENCY OF DETECTION	AVERAGE OF POSITIVE DETECTIONS	MEDIAN OF POSITIVE DETECTIONS
INORGANICS (mg/kg)								
ALUMINUM	NA	NA	2680	15100	3SB08AD-04	12/12	9104.17	9760.00
ANTIMONY	3.7 UL	5.2 UL	5.4 L	5.4 L	3SB15A-12	1/12	5.40	5.40
ARSENIC	NA	NA	0.67 L	38.1 L	3SB019A-07	12/12	8.46	6.10
BARIUM	NA	NA	13.5	54.3	3SB08AD-04	12/12	30.88	24.05
BERYLLIUM	0.17 U	0.17 U	0.17	3.9	3TP02D	11/12	1.16	0.58
CADMIUM	0.41 U	0.58 UL	0.46	0.46	3SB15A-12	1/12	0.46	0.46
CALCIUM	NA	NA	108	225000	3SB15A-12	12/12	42820.92	1485.00
CHROMIUM	NA	NA	3.5 K	65	3SB08AD-04	12/12	29.98	32.30
COBALT	0.63 U	0.68 U	2	39.4	3SB08AD-04	10/12	11.88	4.95
COPPER	NA	NA	1.3	12	3SB08AD-04	12/12	6.53	6.85
IRON	NA	NA	3330	72700	3SB08AD-04	12/12	27394.17	23500.00
LEAD	NA	NA	1.7 L	21.5	3SB019A-07	12/12	10.77	11.15
MAGNESIUM	NA	NA	205	2890	3SB15A-12	12/12	1919.17	2200.00
MANGANESE	NA	NA	6.8	269	3SB08AD-04	12/12	93.93	86.60
MERCURY	0.04 U	0.07 U	0.1	0.1	3TP02D	1/12	0.10	0.10
NICKEL	2.6 U	2.6 U	2.8	31.6	3TP02D	11/12	13.13	7.20
POTASSIUM	156 U	156 U	923 L	3280	3TP02	11/12	2104.82	1940.00
SELENIUM	0.23 U	0.34 U	0.57 L	1.5 L	3SB019A-07	2/12	1.04	1.04
SILVER	0.56 U	0.82 U	0.93	0.93	3TP01	1/12	0.93	0.93
SODIUM	52.7 B	52.7 B	5.5	1330	3SB15A-12	11/12	365.48	48.90
VANADIUM	NA	NA	4.8	84	3SB08AD-04	12/12	31.03	25.00
ZINC	12.5 B	12.5 B	5.3 K	92.4	3TP02D	11/12	42.29	42.40

TABLE 4-23
DEEP GROUNDWATER(1) - POSITIVE DETECTION SUMMARY
ORGANIC COMPOUNDS
SITE 3
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION	3GW06-01	3GW06-01D	3GW07-01	3GW08-01	3GW08A-01	3GW15-01
DATE SAMPLED	02/11/96	02/11/96	02/11/96	02/11/96	02/12/96	02/12/96
VOLATILES (ug/L)						
VINYL CHLORIDE	10 U	10 U	10 U	10 U	10 U	10 U
1,1-DICHLOROETHENE	10 U	10 U	10 U	10 U	10 U	10 U
1,2-DICHLOROETHENE (TOTAL)	10 U	10 U	10 U	10 U	10 U	110
TRICHLOROETHENE	3 J	10 U	3 J	10	10 U	83 B
TOLUENE	10 U	10 U	10 U	10 U	10 U	10 U
SEMIVOLATILES (ug/L)						
PHENANTHRENE	10 U	10 U	10 U	10 U	10 U	2 J
DI-N-OCTYL PHTHALATE	10 U	10 U	10 U	10 U	10 U	10 U

(1) All groundwater samples are from the same aquifer; the "A" designation in the I.D. indicates groundwater samples from deeper monitoring wells.

TABLE 4-23
DEEP GROUNDWATER(1) - POSITIVE DETECTION SUMMARY
ORGANIC COMPOUNDS
SITE 3
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION	3GW15A-01	3GW18-01	3GW18-01D	3GW19-01	3GW19A-01
DATE SAMPLED	02/11/96	02/11/96	02/11/96	02/11/96	02/11/96
VOLATILES (ug/L)					
VINYL CHLORIDE	10 U	10 U	10 U	48	10 U
1,1-DICHLOROETHENE	10 U	10 U	10 U	4 J	10 U
1,2-DICHLOROETHENE (TOTAL)	12	10 U	10 U	570	24
TRICHLOROETHENE	10	10 U	10 U	860	24
TOLUENE	10 U	10 U	10 U	10 U	3 J
SEMIVOLATILES (ug/L)					
PHENANTHRENE	10 U	10 U	10 U	10 U	10 U
DI-N-OCTYL PHTHALATE	10 U	10 U	10 U	10 U	3 J

(1) All groundwater samples are from the same aquifer; the "A" designation in the I.D. indicates groundwater samples from deeper monitoring wells.

TABLE 4-24
DEEP GROUNDWATER(1) - POSITIVE DETECTION SUMMARY
INORGANICS
SITE 3
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION	3GW06-01	3GW06-01D	3GW07-01	3GW08-01	3GW08A-01	3GW15-01
DATE SAMPLED	02/11/96	02/11/96	02/11/96	02/11/96	02/12/96	02/12/96
TOTAL METALS (ug/L)						
ALUMINUM, TOTAL	4410 K	11200 K	3290 K	3210 K	498 K	83.8 K
ARSENIC, TOTAL	13.6	24.6	11.3	9.8	0.9 U	0.9 U
BARIUM, TOTAL	39.9	61	47.8	39.4	25.8	34.8
BERYLLIUM, TOTAL	0.8 U	0.8 U	0.8 U	0.8 U	0.8 U	0.8 U
CADMIUM, TOTAL	2.2 UL	2.2 UL	2.2 U	2.2 U	2.2 UL	2.2 UL
CALCIUM, TOTAL	105000	130000	138000	131000	88900	105000
CHROMIUM, TOTAL	19.9	46.9	18.7	14.3	2.4 U	2.4 U
COBALT, TOTAL	3 U	3.7	4.2	3 U	3 U	3 U
COPPER, TOTAL	4.8	13.3	3.5	2.7	2 U	2 U
IRON, TOTAL	12200	28000	8830	6520	1740	212
LEAD, TOTAL	3.4	9.8	2.6 K	1.8 K	0.8 U	0.8 U
MAGNESIUM, TOTAL	3190	5460	3680	3890	1720	2270
MANGANESE, TOTAL	60.5	118	35	22.6	91.3	73.4
NICKEL, TOTAL	11.3 U	11.3 U	11.3 U	11.3 U	11.3 U	11.3 U
POTASSIUM, TOTAL	2600	4540	2470 L	1730 L	1230	4240
SELENIUM, TOTAL	1.4 L	1.7	1.3 U	1.3 U	1.3 U	1.3 U
SODIUM, TOTAL	6050	6480	10400	9630	8530	11200
VANADIUM, TOTAL	26.2	54.1	23.5	19.1	5.9	2.4 U
ZINC, TOTAL	21.7	49	18	15.3	3.6	3.6 U

(1) All groundwater samples are from the same aquifer; the "A" designation in the I.D. indicates groundwater samples from deeper monitoring wells.

TABLE 4-24
DEEP GROUNDWATER(1) - POSITIVE DETECTION SUMMARY
INORGANICS
SITE 3
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION	3GW15A-01	3GW18-01	3GW18-01D	3GW19-01	3GW19A-01
DATE SAMPLED	02/11/96	02/11/96	02/11/96	02/11/96	02/11/96
TOTAL METALS (ug/L)					
ALUMINUM, TOTAL	432 K	1660 K	1740 K	32300 K	6780 K
[redacted]					
BERYLLIUM, TOTAL	0.8 U	0.8 U	0.8 U	2.3	0.8 U
CADMIUM, TOTAL	2.2 U	2.2 U	2.2 U	2.5 L	2.2 UL
CALCIUM, TOTAL	86500	77800	83500	252000	108000
CHROMIUM, TOTAL	3.7	2.4 U	2.4 U	177	41.6
COBALT, TOTAL	3 U	3.3	3 U	13.5	3 U
COPPER, TOTAL	5.3	7.1	6.9	31.5	9
IRON, TOTAL	2100	1130	1440	91100	16400
LEAD, TOTAL	0.8 U	0.8 U	3.2	22	5.7
MAGNESIUM, TOTAL	1590	390	460	14200	4220
MANGANESE, TOTAL	106	3.6	5.6	621	119
NICKEL, TOTAL	11.3 U	11.3 U	11.3 U	58.6	11.3 U
POTASSIUM, TOTAL	2470 L	4090	3540 L	11800	4520
SELENIUM, TOTAL	1.3 U	1.3 U	1.5	1.3 U	1.3 U
SODIUM, TOTAL	7880	11300	11300	9880	21200
VANADIUM, TOTAL	2.4 U	9.5	6.6	225	32.1
ZINC, TOTAL	13.6	4.8	6.6	180	44.7

(1) All groundwater samples are from the same aquifer; the "A" designation in the I.D. indicates groundwater samples from deeper mon

TABLE 4-24
DEEP GROUNDWATER - POSITIVE DETECTION SUMMARY .
DISSOLVED INORGANICS
SITE 3
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION	3GW06F-01	3GW06F-01D	3GW07F-01	3GW08AF-01	3GW08F-01	3GW15AF-01
DATE SAMPLED	02/11/96	02/11/96	02/11/96	02/12/96	02/11/96	02/11/96
DISSOLVED METALS (ug/L)						
ALUMINUM, SOLUBLE	23.3 U	23.3 U	30 K	23.3 U	23.9 K	23.3 U
ARSENIC, SOLUBLE	1	1.2	0.9 U	0.9 U	1.4	0.9 U
BARIUM, SOLUBLE	20.6	20.9	34.1	23.9	27.6	23.9
CADMIUM, SOLUBLE	2.2 UL	2.2 UL	2.2 U	2.2 UL	2.9 K	2.2 U
CALCIUM, SOLUBLE	77500	80200	119000	83800	118000	78200
CHROMIUM, SOLUBLE	2.4 U	2.4 U	2.4 U	7.3	2.4 U	2.4 U
COPPER, SOLUBLE	2 U	2 U	2 U	2 U	2 U	2 U
IRON, SOLUBLE	52.9	47.4	42.2	238	28.9	9.7 U
MAGNESIUM, SOLUBLE	1650	1820	2590	1560	2930	1400
MANGANESE, SOLUBLE	14.4	14.8	1.6 U	88.3	2.1	95.6
POTASSIUM, SOLUBLE	828 U	1390	948 L	1190	828 UL	1920 L
SODIUM, SOLUBLE	5950	6100	9990	8640	9970	7680
VANADIUM, SOLUBLE	2.4 U	2.7	2.4 U	.5	2.4 U	2.4 U

TABLE 4-24
DEEP GROUNDWATER - POSITIVE DETECTION SUMMARY
DISSOLVED INORGANICS
SITE 3
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION	3GW15F-01	3GW18F-01	3GW18F-01D	3GW19AF-01	3GW19F-01
DATE SAMPLED	02/12/96	02/11/96	02/11/96	02/11/96	02/11/96
DISSOLVED METALS (ug/L)					
ALUMINUM, SOLUBLE	23.3 U	1100 K	1110 K	23.3 U	23.3 U
ARSENIC, SOLUBLE	0.9 U	2.5 K	2.7	0.9 U	0.9 U
BARIUM, SOLUBLE	33.8	34.7	35.1	23.6	30.1
CADMIUM, SOLUBLE	2.2 UL	2.2 U	2.2 U	2.2 UL	2.2 UL
CALCIUM, SOLUBLE	106000	66100	68300	69700	127000
CHROMIUM, SOLUBLE	2.4 U	2.4 U	2.4 U	2.4 U	2.4 U
COPPER, SOLUBLE	2 U	2 U	2 U	2 U	3.9
IRON, SOLUBLE	9.7 U	12.3	14	9.7 U	76.3
MAGNESIUM, SOLUBLE	2220	26.9 U	30.4 B	1510	4390
MANGANESE, SOLUBLE	81.3	1.8	1.6 U	51.3	204
POTASSIUM, SOLUBLE	3660	3670 L	3760 L	2390	1430
SODIUM, SOLUBLE	9260	11400	11400	20600	8820
VANADIUM, SOLUBLE	2.8	5.5	5.5	5.3	2.4 U

TABLE 4-25
GROUNDWATER - POSITIVE DETECTION SUMMARY
ENGINEERING PARAMETERS
SITE 3
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION	3GW06-01	3GW06-01D	3GW07-01	3GW08-01	3GW08A-01	3GW15-01
DATE SAMPLED	02/11/96	02/11/96	02/11/96	02/11/96	02/12/96	02/12/96
ENGINEERING (mg/L)						
NITRATE NITRITE	0.1 U	0.1 U	0.13	0.53	0.1 U	0.16
TKN	1.3	1.7	1.3	1.3	1.1	1.2
TOTAL ORGANIC CARBON	1.1	1	1	1 U	1	1.3
TOC TEST 2	1.2	1 U	1 U	1.1	1	1.3
TOTAL DISSOLVED SOLIDS	300	340	420	430	290	340
TOTAL SUSPENDED SOLIDS	570	1500	270	350	24	5 U

TABLE 4-25
GROUNDWATER - POSITIVE DETECTION SUMMARY
ENGINEERING PARAMETERS
SITE 3
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION	3GW15A-01	3GW18-01	3GW18-01D	3GW19-01	3GW19A-01
DATE SAMPLED	02/11/96	02/11/96	02/11/96	02/11/96	02/11/96
ENGINEERING (mg/L)					
NITRATE NITRITE	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
TKN	1.1	1.2	0.91	1.7	1.8
TOTAL ORGANIC CARBON	3.8	1.4	1.4	3.6	3.8
TOC TEST 2	3.8	1.2	1.2	3.4	3.9
TOTAL DISSOLVED SOLIDS	270	230	230	430	420
TOTAL SUSPENDED SOLIDS	160	200	220	1100	430

TABLE 4-26

SUMMARY OF TEST PIT FINDINGS
SITES 1 AND 3
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Location	Test Pit Number	Depth (feet/bgs)	Material Encountered
Site 1	1TP01	4.5	Natural soil - coarse to fine sand, some silt
	1TP02	7.5	Scrap metal, lumber, tree limbs, construction rubble, packaging wastes
	1TP03	8	Scrap metal, metal banding, lense grinding debris
	1TP04	7.5	Scrap metal, tree limbs, construction rubble
Site 3	3TP01	5	Fill material - coarse to fine sand, some silt
	3TP02	10	Scrap metal, 55-gal metal drums, grease, wax, lumber, animal carcass
	3TP03	5	Surface debris-metal, banding, concrete block, plastic sheeting
	3TP04	5	Surface debris - construction rubble

FIGURES

LOCATION	15S06
DATE SAMPLED	01/24/96
DEPTH	0-0.5'
SEMIVOLATILES (ug/kg)	
FLUORANTHENE	190 J
PYRENE	180 J
CHRYSENE	84 J
BENZO(A)ANTHRACENE	110 J
BENZO(B)FLUORANTHENE	160 J

LOCATION	15S07
DATE SAMPLED	01/24/96
DEPTH	0-0.5'
SEMIVOLATILES (ug/kg)	
FLUORANTHENE	160 J
PYRENE	120 J
BENZO(A)ANTHRACENE	56 J
CHRYSENE	86 J
BENZO(B)FLUORANTHENE	140 J
BENZO(K)FLUORANTHENE	64 J
BENZO(A)PYRENE	70 J

LOCATION	
DATE SAMPLED	01/23/
DEPTH	0-0.
SEMIVOLATILES (ug/kg)	
PHENANTHRENE	2
ANTHRACENE	
FLUORANTHENE	2
PYRENE	1
BENZO(A)ANTHRACENE	
CHRYSENE	1

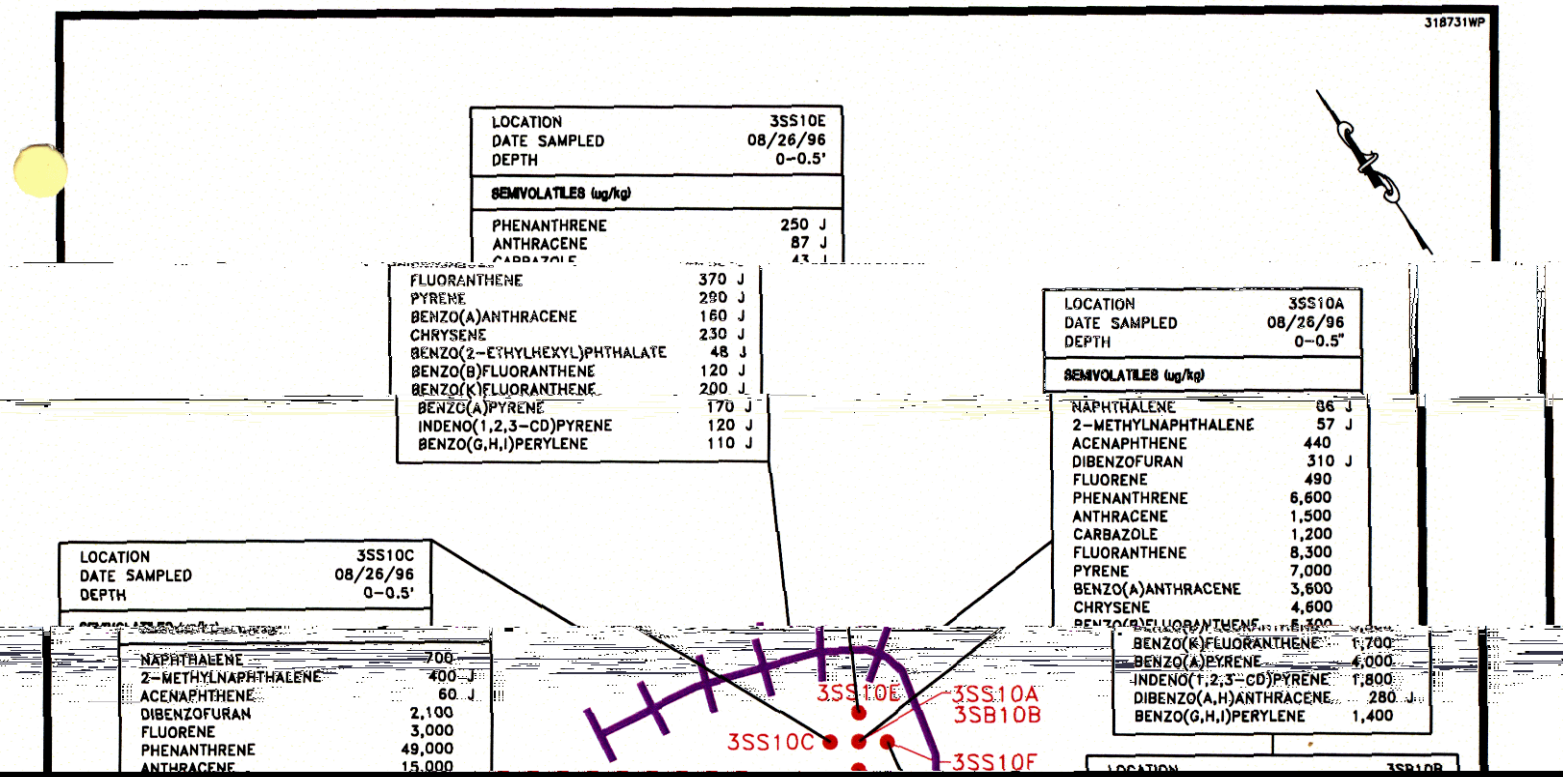
WOODS

WOODS

WOODS

15SW13A

318701WP


LOCATION 3SS10E
DATE SAMPLED 08/26/96
DEPTH 0-0.5'
SEMIVOLATILES (ug/kg)
PHENANTHRENE 250 J
ANTHRACENE 87 J
FLUORANTHENE 370 J
PYRENE 280 J
BENZO(A)ANTHRACENE 160 J
CHRYSENE 230 J
BENZO(2-ETHYLHEXYL)PHTHALATE 48 J
BENZO(B)FLUORANTHENE 120 J
BENZO(K)FLUORANTHENE 200 J
BENZO(A)PYRENE 170 J
INDENO(1,2,3-CD)PYRENE 120 J
BENZO(G,H,I)PERYLENE 110 J
LOCATION 3SS10A
DATE SAMPLED 08/26/96
DEPTH 0-0.5"
SEMIVOLATILES (ug/kg)
NAPHTHALENE 86 J
2-METHYLNAPHTHALENE 57 J
ACENAPHTHENE 440
DIBENZOFURAN 310 J
FLUORENE 490
PHENANTHRENE 6,600
ANTHRACENE 1,500
CARBAZOLE 1,200
FLUORANTHENE 8,300
PYRENE 7,000
BENZO(A)ANTHRACENE 3,600
CHRYSENE 4,600
BENZO(K)FLUORANTHENE 1,700
BENZO(A)PYRENE 4,000
INDENO(1,2,3-CD)PYRENE 1,800
DIBENZO(A,H)ANTHRACENE 280 J
BENZO(G,H,I)PERYLENE 1,400
LOCATION 3SS10C
DATE SAMPLED 08/26/96
DEPTH 0-0.5'
NAPHTHALENE 700
2-METHYLNAPHTHALENE 400 J
ACENAPHTHENE 60 J
DIBENZOFURAN 2,100
FLUORENE 3,000
PHENANTHRENE 49,000
3SS10E
3SS10A
3SB10B
3SS10C
3SS10F

318702WP

SITE 1

SITE 3

WOODS

DIRT ROAD

DIRT MOUND

POND

DEBRIS AREA

INDIAN FIELD CREEK

EDGE OF WATER

MAG. BLDG. 266

GATE

1SS07 1SS09 1SS08 1SS10 1SS13 1SS16 1SS17 1SS18 1SS15 1SS12 1SS14 1SS11

1GW13A 1GW19 1GW18 1GW12A 1GW21 1GW20

3SS11 3SS14 3SS13 3SS10 3SS12 3SS09 3SS05 3SS08 3SS07 3SS06 3SS04

3GW19A 3GW08A 3GW07 3GW15A 3GW06

LOCATION	1SS07
DATE SAMPLED	01/24/96
DEPTH	0–0.5'
TOTAL INORGANICS (mg/kg)	
ARSENIC	1.7
BERYLLIUM	0.22
IRON	4220

LOCATION	1SS07D
DATE SAMPLED	01/24/96
DEPTH	0–0.5'
TOTAL INORGANICS (mg/kg)	
ARSENIC	1.9
BERYLLIUM	0.28
IRON	4000

LOCATION	1SS08
DATE SAMPLED	01/24/96
DEPTH	0–0.5'
TOTAL INORGANICS (mg/kg)	
ARSENIC	1.3
BERYLLIUM	0.25
IRON	4480

LOCATION	1SS09
DATE SAMPLED	01/24/96
DEPTH	0–0.5'
TOTAL INORGANICS (mg/kg)	
ARSENIC	3.1
BERYLLIUM	0.28
IRON	5620

LOCATION	1SB13A–00
DATE SAMPLED	01/23/96
DEPTH	0–0.5'
TOTAL INORGANICS (mg/kg)	
ARSENIC	1.1
BERYLLIUM	0.37
IRON	3530

LOCATION	1SB13AD–00
DATE SAMPLED	01/23/96
DEPTH	0–0.5'
TOTAL INORGANICS (mg/kg)	
ARSENIC	0.99
BERYLLIUM	0.5
IRON	3610

LOCATION	1SS13
DATE SAMPLED	01/23/96
DEPTH	0–0.5'
TOTAL INORGANICS (mg/kg)	
ARSENIC	3.1
BERYLLIUM	0.28
IRON	9310

LOCATION	1SS16
DATE SAMPLED	01/23/96
DEPTH	0–0.5'
TOTAL INORGANICS (mg/kg)	
ARSENIC	1.3 L
IRON	3070

LOCATION	1SS17
DATE SAMPLED	01/23/96
DEPTH	0–0.5'
TOTAL INORGANICS (mg/kg)	
ARSENIC	3.8 L
BERYLLIUM	0.37
IRON	7740

LOCATION	1SS18
DATE SAMPLED	01/23/96
DEPTH	0–0.5'
TOTAL INORGANICS (mg/kg)	
ALUMINUM	8950
ARSENIC	43.5 L
BERYLLIUM	0.39
IRON	10100

LOCATION	1SB18–00
DATE SAMPLED	01/24/96
DEPTH	0–0.5'
TOTAL INORGANICS (mg/kg)	
ALUMINUM	11200
ARSENIC	7.2
BERYLLIUM	0.47
IRON	11700

LOCATION	1SB19–00
DATE SAMPLED	01/23/96
DEPTH	0–0.5'
TOTAL INORGANICS (mg/kg)	
ARSENIC	6.1
BERYLLIUM	0.55
IRON	5450

LOCATION	1SB21–00
DATE SAMPLED	01/23/96
DEPTH	0–0.5'
TOTAL INORGANICS (mg/kg)	
ARSENIC	1.4
BERYLLIUM	0.27
IRON	5300

LOCATION	1SB12A–00
DATE SAMPLED	01/23/96
DEPTH	0–0.5'
TOTAL INORGANICS (mg/kg)	
ARSENIC	92.5
BERYLLIUM	0.33
IRON	7780

LOCATION	1SB20–00
DATE SAMPLED	01/23/96
DEPTH	0–0.5'
TOTAL INORGANICS (mg/kg)	
ARSENIC	0.64 L
BERYLLIUM	0.21
IRON	2510

LOCATION	1SS11
DATE SAMPLED	01/23/96
DEPTH	0–0.5'
TOTAL INORGANICS (mg/kg)	
ARSENIC	1.8
IRON	3970

LOCATION	1SS14
DATE SAMPLED	01/23/96
DEPTH	0–0.5'
TOTAL INORGANICS (mg/kg)	
ARSENIC	1.7 L
IRON	4210

LOCATION	1SS140
DATE SAMPLED	01/23/96
DEPTH	0–0.5'
TOTAL INORGANICS (mg/kg)	
ARSENIC	1.4 L
IRON	3980

LOCATION	1SS12
DATE SAMPLED	01/23/96
DEPTH	0–0.5'
TOTAL INORGANICS (mg/kg)	
ARSENIC	2.7
IRON	7100

LOCATION	1SS15
DATE SAMPLED	01/23/96
DEPTH	0–0.5'
TOTAL INORGANICS (mg/kg)	
ARSENIC	1.2 L
IRON	3280

LOCATION	3SS04
DATE SAMPLED	01/29/96
DEPTH	0–0.5'
TOTAL INORGANICS (mg/kg)	
ARSENIC	1.2
BERYLLIUM	0.39
IRON	3440

LOCATION	3SS04D
DATE SAMPLED	01/29/96
DEPTH	0–0.5'
TOTAL INORGANICS (mg/kg)	
ARSENIC	1.5
BERYLLIUM	0.58
IRON	3770

LOCATION	3SS14
DATE SAMPLED	01/30/96
DEPTH	0–0.5'
TOTAL INORGANICS (mg/kg)	
ARSENIC	1.4
BERYLLIUM	0.57
IRON	2500

LOCATION	3SB15A–00
DATE SAMPLED	01/29/96
DEPTH	0–0.5'
TOTAL INORGANICS (mg/kg)	
ARSENIC	1.8
BERYLLIUM	0.2
IRON	2530

LOCATION	3SS06
DATE SAMPLED	01/26/96
DEPTH	0–0.5'
TOTAL INORGANICS (mg/kg)	
ALUMINUM	8840
ARSENIC	4.7
BERYLLIUM	0.47
CHROMIUM	22
IRON	16200

LOCATION	3SS07
DATE SAMPLED	01/27/96
DEPTH	0–0.5'
TOTAL INORGANICS (mg/kg)	
ARSENIC	2.1
IRON	11400

LOCATION	3SB19A–00
DATE SAMPLED	01/30/96
DEPTH	0–0.5'
TOTAL INORGANICS (mg/kg)	
ARSENIC	1.5
BERYLLIUM	0.44
IRON	2460

LOCATION	3SS13
DATE SAMPLED	01/27/96
DEPTH	0–0.5'
TOTAL INORGANICS (mg/kg)	
ARSENIC	6.9
BERYLLIUM	0.46
IRON	16800

LOCATION	3SS11
DATE SAMPLED	01/30/96
DEPTH	0–0.5'
TOTAL INORGANICS (mg/kg)	
ANTIMONY	4.8 L
ARSENIC	1.8
BERYLLIUM	0.55
IRON	3350

LOCATION	3SS110
DATE SAMPLED	01/30/96
DEPTH	0–0.5'
TOTAL INORGANICS (mg/kg)	
ANTIMONY	16.8 L
ARSENIC	1.7
BERYLLIUM	0.38
IRON	3150

LOCATION	3SB08A–00
DATE SAMPLED	02/08/96
DEPTH	0–0.5'
TOTAL INORGANICS (mg/kg)	
ARSENIC	5 L
BERYLLIUM	0.58 K
IRON	23900
MANGANESE	244

LOCATION	3SS10
DATE SAMPLED	01/27/96
DEPTH	0–0.5'
TOTAL INORGANICS (mg/kg)	
ALUMINUM	10100
ARSENIC	9.5
BERYLLIUM	0.98
IRON	8040
MANGANESE	1580
VANADIUM	142

LOCATION	3SS12
DATE SAMPLED	01/27/96
DEPTH	0–0.5'
TOTAL INORGANICS (mg/kg)	
ALUMINUM	11800
ARSENIC	5.2
BERYLLIUM	0.53
CHROMIUM	31.8 K
IRON	19700

LOCATION	3SS09
DATE SAMPLED	01/26/96
DEPTH	0–0.5'
TOTAL INORGANICS (mg/kg)	
ARSENIC	3.6
BERYLLIUM	0.36
IRON	7700

LOCATION	3SS08
DATE SAMPLED	01/26/96
DEPTH	0–0.5'
TOTAL INORGANICS (mg/kg)	
ARSENIC	1.2
BERYLLIUM	1.5
IRON	3040
MANGANESE	667

LOCATION	3SS07
DATE SAMPLED	01/27/96
DEPTH	0–0.5'
TOTAL INORGANICS (mg/kg)	
ARSENIC	1.9
IRON	5190

1 inch = 180 ft

180 0 90 180

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LEGEND

- EDGE OF WATER
- TREELINE
- EDGE OF PAVEMENT
- BUILDING
- WETLANDS
- DEBRIS AREA
- REMEDIAL INVESTIGATION SITE
- 3SS04 – SURFACE SOIL SAMPLE LOCATION
- 1GW11 – MONITORING WELL/SOIL BORING LOCATION

SOURCE: PHR & A, AUGUST 1995.

FIGURE 4–2
POSITIVE DETECTIONS OF SELECT INORGANIC ANALYTES IN SURFACE SOIL
SITES 1 AND 3
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

318700WP

LOCATION	1SB19-01
DATE SAMPLED	01/23/96
DEPTH	1-3'
PESTICIDE/PCBS (ug/kg)	
DIELDRIN	4 J
4,4'-DDE	16 J
4,4'-DDD	7.4 J
4,4'-DDT	48 J
ALPHA-CHLORDANE	4.4 J
GAMMA-CHLORDANE	3.7 J

LOCATION	1SB19-02
DATE SAMPLED	01/23/96
DEPTH	3-5'
PESTICIDE/PCBS (ug/kg)	
AROCLOR-1260	27 J

LOCATION	3SB15A-12
DATE SAMPLED	01/29/96
DEPTH	23-25'
SEMIVOLATILES (ug/kg)	
2-METHYLNAPHTHALENE	180 J
FLUORENE	300 J
PHENANTHRENE	1400
PYRENE	140 J
CHRYSENE	44 J
PESTICIDE/PCBS (ug/kg)	
BETA-BHC	1.7 J
DELTA-BHC	1.7 J
4,4'-DDE	3.8 J
ENDRIN	4.2
ENDOSULFAN II	5
4,4'-DDT	3.4 J

LOCATION	3TP02
DATE SAMPLED	01/26/96
DEPTH	8-9'
VOLATILES (ug/kg)	
METHYLENE CHLORIDE	15
ACETONE	930 J
1,2-DICHLOROETHENE (TOTAL)	160
ETHYLBENZENE	6 J

4-METHYLPHENOL	250 J
2-METHYLNAPHTHALENE	380 J
FLUORENE	67 J
PHENANTHRENE	160 J

LOCATION	3TP02D
DATE SAMPLED	01/26/96
DEPTH	8-9'
VOLATILES (ug/kg)	
ACETONE	770 J
1,2-DICHLOROETHENE (TOTAL)	200
ETHYLBENZENE	2 J
SEMIVOLATILES (ug/kg)	
4-METHYLPHENOL	210 J
2-METHYLNAPHTHALENE	150 J
PHENANTHRENE	110 J
PESTICIDE/PCBS (ug/kg)	
4,4'-DDE	4.6 J
4,4'-DDD	4.2 J

CATION	1SB18-01
TE SAMPLED	01/24/96
PTH	1-3'
MIVOLATILES (ug/kg)	
JORANTHENE	100 J
RENE	120 J
NZO(A)ANTHRACENE	63 J
RYSENE	96 J
NZO(B)FLUORANTHENE	120 J
NZO(K)FLUORANTHENE	55 J
NZO(A)PYRENE	59 J
DENO(1,2,3-CD)PYRENE	70 J
NZO(G,H,I)PERYLENE	60 J

CATION	1SB12A-01
E SAMPLED	01/24/96
TH	1-3'
IVOLATILES (ug/kg)	
CNANTHRENE	54 J
ORANTHENE	300 J
ENE	310 J
ZO(A)ANTHRACENE	120 J
YSENE	210 J
ZO(B)FLUORANTHENE	270 J
ZO(K)FLUORANTHENE	120 J
ZO(A)PYRENE	130 J
ENO(1,2,3-CD)PYRENE	140 J
ZO(G,H,I)PERYLENE	120 J

ATION	1SB12AD-01
E SAMPLED	01/24/96
TH	1-3'
IVOLATILES (ug/kg)	
FLUORANTHENE	83 J
PYRENE	100 J
BENZO(A)ANTHRACENE	46 J
CHRYSENE	85 J
BENZO(B)FLUORANTHENE	130 J
BENZO(K)FLUORANTHENE	57 J
BENZO(A)PYRENE	59 J
INDENO(1,2,3-CD)PYRENE	66 J
BENZO(G,H,I)PERYLENE	61 J

LOCATION	1SB21-09
DATE SAMPLED	01/24/96
DEPTH	17-19'
SEMIVOLATILES (ug/kg)	
DIETHYLPHTHALATE	190000

LOCATION	1SB20-01
DATE SAMPLED	01/23/96
DEPTH	1-3'
PESTICIDE/PCBS (ug/kg)	
AROCLOR-1260	25 J

1GW13A
1GW13
01GW19
01GW18
1GW12
01GW21
01GW20
3GW19
3GW19A
3GW08A
3GW15A
TEST PIT #1/01
TEST PIT #1/02
TEST PIT #1/03
TEST PIT # 1/04
TEST PIT #3/02
TEST PIT #3/04
TEST PIT #3/03
TEST PIT #3/04
DIRT ROAD
DIRT MOUND
DEBRIS AREA
WOODS
INDIAN FIELD CREEK
EDGE OF WATER
MAG. BLDG. 266
MAG. BLDG. 267
GATE

200 0 100 200
1 inch = 200 ft.

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Baker Environmental, Inc.

NOTES:

1. ELEVATIONS SHOWN WERE TAKEN FROM AN ALUMINUM RIVET LOCATED IN CONCRETE HEADWALL N. OF N. RD. TO AMMO

LEGEND

FIGURE 4-3

318704WP

LOCATION	1TP01
DATE SAMPLED	01/25/96
DEPTH	4–5'
TOTAL INORGANICS (ug/kg)	
ARSENIC	0.51

LOCATION	1TP03
DATE SAMPLED	01/25/96
DEPTH	7–8'
TOTAL INORGANICS (ug/kg)	
ARSENIC	0.84

LOCATION	1SB13A–01
DATE SAMPLED	01/25/96
DEPTH	1–3'
TOTAL INORGANICS (ug/kg)	
ARSENIC	1.9
BERYLLIUM	0.28
IRON	7630

LOCATION	1SB13AD–01
DATE SAMPLED	01/25/96
DEPTH	1–3'
TOTAL INORGANICS (ug/kg)	
ARSENIC	1.5
BERYLLIUM	0.17
IRON	6230

LOCATION	3SB019A–07
DATE SAMPLED	02/07/96
DEPTH	13–15'
TOTAL INORGANICS (mg/kg)	
ALUMINUM	9780
ARSENIC	38.1 L
IRON	42900
VANADIUM	71

LOCATION	3SB019A–14
DATE SAMPLED	02/07/96
DEPTH	27–29'
TOTAL INORGANICS (mg/kg)	
ARSENIC	3.1 L
BERYLLIUM	0.31 K
IRON	13000

LOCATION	3SB08A–04
DATE SAMPLED	02/08/96
DEPTH	7–9'
TOTAL INORGANICS (mg/kg)	
ALUMINUM	10300
ARSENIC	13.2 L
BERYLLIUM	1.5 K
IRON	34500

LOCATION	3SB08AD–04
DATE SAMPLED	02/08/96
DEPTH	7–9'
TOTAL INORGANICS (mg/kg)	
ALUMINUM	15100
ARSENIC	4 L
BERYLLIUM	2.3
CHROMIUM	65
IRON	72700
MANGANESE	269
VANADIUM	84

LOCATION	3SB08A–09
DATE SAMPLED	02/08/96
DEPTH	17–19'
TOTAL INORGANICS (mg/kg)	
ARSENIC	2.4 L
BERYLLIUM	0.49 K
IRON	17600

LOCATION	3TP03
DATE SAMPLED	01/26/96
DEPTH	3–4'
TOTAL INORGANICS (mg/kg)	
ALUMINUM	14500
ARSENIC	1.3 L
BERYLLIUM	0.23
IRON	13200

LOCATION	1TP04
DATE SAMPLED	01/25/96
DEPTH	7–8'
TOTAL INORGANICS (ug/kg)	
ARSENIC	2.7
IRON	4620

LOCATION	1TP02
DATE SAMPLED	01/25/96
DEPTH	7–8'
TOTAL INORGANICS (ug/kg)	
ARSENIC	1.2
IRON	3920

LOCATION	1TP04D
DATE SAMPLED	01/25/96
DEPTH	7–8'
TOTAL INORGANICS (ug/kg)	
ARSENIC	1.3
BERYLLIUM	0.23

LOCATION	1SB19–01
DATE SAMPLED	01/23/96
DEPTH	1–3'
TOTAL INORGANICS (ug/kg)	
ARSENIC	2.3 L
BERYLLIUM	0.18
IRON	7560

LOCATION	1SB19–02
DATE SAMPLED	01/23/96
DEPTH	3–5'
TOTAL INORGANICS (ug/kg)	
ARSENIC	1 L
IRON	3020

LOCATION	1SB18–01
DATE SAMPLED	01/24/96
DEPTH	1–3'
TOTAL INORGANICS (ug/kg)	
ARSENIC	36 L
BERYLLIUM	0.38
IRON	9450

LOCATION	1SB12A–01
DATE SAMPLED	01/24/96
DEPTH	1–3'
TOTAL INORGANICS (ug/kg)	
ARSENIC	24.2 L
BERYLLIUM	0.23
IRON	3920

LOCATION	1SB12AD–01
DATE SAMPLED	01/24/96
DEPTH	1–3'
TOTAL INORGANICS (ug/kg)	
ARSENIC	126 L
BERYLLIUM	0.27
IRON	5020

LOCATION	1SB21–06
DATE SAMPLED	01/24/96
DEPTH	17–19'
TOTAL INORGANICS (ug/kg)	
ALUMINUM	13000
ARSENIC	8.2
BERYLLIUM	1.1
IRON	25700

LOCATION	1SB21–09
DATE SAMPLED	01/24/96
DEPTH	20–23'
TOTAL INORGANICS (ug/kg)	
ALUMINUM	9860
ANTIMONY	4.4 L
ARSENIC	8.8
BERYLLIUM	0.75
IRON	26300
MANGANESE	364

LOCATION	1SB20–01
DATE SAMPLED	01/23/96
DEPTH	11–13'
TOTAL INORGANICS (ug/kg)	
BERYLLIUM	0.24

LOCATION	3TP01
DATE SAMPLED	01/26/96
DEPTH	3–4'
TOTAL INORGANICS (mg/kg)	
ALUMINUM	13000
ARSENIC	6.1 L
BERYLLIUM	0.56
CHROMIUM	41.1 K
IRON	40600

LOCATION	3TP02
DATE SAMPLED	01/26/96
DEPTH	8–9'
TOTAL INORGANICS (mg/kg)	
ALUMINUM	9740
ARSENIC	7.8 L
BERYLLIUM	2.1
IRON	29400

LOCATION	3TP02D
DATE SAMPLED	01/26/96
DEPTH	8–9'
TOTAL INORGANICS (mg/kg)	
ALUMINUM	9910
ARSENIC	8.5 L
BERYLLIUM	3.9
IRON	33500

LOCATION	3SB15A–08
DATE SAMPLED	01/29/96
DEPTH	15–17'
TOTAL INORGANICS (mg/kg)	
ALUMINUM	9670
ARSENIC	10.3 J
BERYLLIUM	0.58
IRON	15600

LOCATION	3SB15A–12
DATE SAMPLED	01/29/96
DEPTH	23–25'
TOTAL INORGANICS (mg/kg)	
ANTIMONY	5.4 L
ARSENIC	6.1 J
BERYLLIUM	0.59
IRON	12300

LOCATION	3TP04
DATE SAMPLED	01/26/96
DEPTH	3–4'
TOTAL INORGANICS (mg/kg)	
ARSENIC	0.67 L
BERYLLIUM	0.17
IRON	3330

1GW13A
SITE 1
TEST PIT #1/01
TEST PIT # 1/02
TEST PIT #1/03
TEST PIT # 1/04
01GW19
01GW18
01GW12A
01GW21
01GW20
3GW19A
3GW08A
3GW10A
SITE 3
TEST PIT #3/02
TEST PIT #3/03
TEST PIT #3/01
TEST PIT #3/04
WOODS
DIRT ROAD
DIRT MOUND
POND
DEBRIS AREA
INDIAN FIELD CREEK
EDGE OF WATER
MAG. BLDG. 266
MAG. BLDG. 267
GATE

200 0 100 200
1 inch = 200 ft.

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LEGEND

1GW17 — MONITORING WELL
TEST PIT #1/04 — TEST PIT
REMEDIAL INVESTIGATION SITE
TREELINE
EDGE OF PAVEMENT
BUILDING
DEBRIS AREA

FIGURE 4–4
POSITIVE DETECTIONS OF SELECT INORGANIC ANALYTES IN SUBSURFACE SOIL SITES 1 AND 3

SOURCE: PHR & A, AUGUST 1995.

YORKTOWN
NIA

NAVAL WEAPONS STATION
YORKTOWN, VIRGIN

318712WP

LOCATION	1GW17-01
DATE SAMPLED	02/08/96
NITRAMINES (ug/L)	
NITROBENZENE	0.7

LOCATION	1GW14-01
DATE SAMPLED	02/08/96
NITRAMINES (ug/L)	
NITROBENZENE	1.4

LOCATION	1GW19-01
DATE SAMPLED	01/25/96
VOLATILES (ug/L)	
TRICHLOROETHENE	4 J

LOCATION	1GW18-01
DATE SAMPLED	01/25/96 *
NITRAMINES (ug/L)	
NITROBENZENE	1.3

LOCATION	1GW12-01
DATE SAMPLED	02/09/96 *
VOLATILES (ug/L)	
1,2-DICHLOROETHENE (TOTAL)	4 J
TRICHLOROETHENE	64 B

LOCATION	11GW11-01
DATE SAMPLED	02/10/96
SEMIVOLATILES (ug/L)	
PENTACHLOROPHENOL	1 J

LOCATION	1GW20-01
DATE SAMPLED	01/25/96 *
VOLATILES (ug/L)	
1,2-DICHLOROETHENE (TOTAL)	52
TRICHLOROETHENE	190

1GW17 1GW13 1GW14 01GW19 01GW18 1GW12 01GW20 11GW11 1GW05 1GW04

SITE 1 SITE 3

WOODS DIRT ROAD DIRT MOUND POND DEBRIS AREA MAG. BLDG. 256 MAG. BLDG. 267 GATE INDIAN FIELD CREEK

200 0 100 200
1 inch = 200 ft.

Baker
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LEGEND

1GW17 MONITORING WELL
REMEDIAL INVESTIGATION SITE
TREELINE
EDGE OF PAVEMENT
BUILDING
DEBRIS AREA

SOURCE: PHR & A, AUGUST 1995.

FIGURE 4-5
POSITIVE DETECTIONS OF SELECT ORGANIC COMPOUNDS IN SHALLOW GROUNDWATER
SITE 1
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

318713WP

LOCATION	1GW19F-01
DATE SAMPLED	02/09/96
DISSOLVED INORGANICS (ug/L)	
ARSENIC	1.7
IRON	1970

LOCATION	1GW19-01
DATE SAMPLED	02/09/96
TOTAL INORGANICS (ug/L)	
ARSENIC	3.9
IRON	3840

LOCATION	1GW18F-01
DATE SAMPLED	02/09/96
DISSOLVED INORGANICS (ug/L)	
ARSENIC	4.4 L
IRON	54900
MANGANESE	1530

LOCATION	1GW18-01
DATE SAMPLED	02/09/96
TOTAL INORGANICS (ug/L)	
ARSENIC	3.5
IRON	55300
MANGANESE	1500

LOCATION	1GW17-01
DATE SAMPLED	02/08/96
TOTAL INORGANICS (ug/L)	
IRON	1210
MANGANESE	90.6

LOCATION	1GW13-01
DATE SAMPLED	02/10/96
TOTAL INORGANICS (ug/L)	
IRON	2520

LOCATION	1GW05F-01
DATE SAMPLED	02/10/96
DISSOLVED INORGANICS (ug/L)	
ARSENIC	1.8 L
IRON	4760
MANGANESE	102

LOCATION	1GW05-01
DATE SAMPLED	02/10/96
TOTAL INORGANICS (ug/L)	
ARSENIC	1.3 L
IRON	5060
MANGANESE	99.5

LOCATION	1GW04F-01D
DATE SAMPLED	02/10/96
DISSOLVED INORGANICS (ug/L)	
ARSENIC	1.2 L

LOCATION	1GW04-01
DATE SAMPLED	02/10/96
TOTAL INORGANICS (ug/L)	
ARSENIC	1.7 L
IRON	1600

LOCATION	1GW04-01D
DATE SAMPLED	02/10/96
TOTAL INORGANICS (ug/L)	
ARSENIC	2.1 L
IRON	1990

1GW12F-01
02/09/96
9
803
2850

GW12-01
02/09/96
1.1 L
8.6
821
2960

LOCATION	
DATE SAMPLED	
DISSOLVED INORGANICS (ug/L)	
CADMIUM	
MANGANESE	
ZINC	

LOCATION	
DATE SAMPLED	
TOTAL INORGANICS (ug/L)	
ARSENIC	
CADMIUM	
MANGANESE	
ZINC	

SITE 1

SITE 3

1GW17 1GW13 1GW05 1GW14 01GW19 01GW18 1GW04 1GW12 01GW20 11GW11 11GW11A

1SG01 1SG02 1SG03 1SG04 1SG05

INDIAN FIELD CREEK

WOODS DIRT ROAD DIRT MOUND POND DEBRIS AREA EDGE OF WATER EDGE OF MARSH GATE MAG. BLDG. 268 MAG. BLDG. 267

200 0 100 200
1 inch = 200 ft.

Baker
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LEGEND

1GW17 MONITORING WELL
1SG01 STAFF GAUGE
REMEDIAL INVESTIGATION SITE
TREELINE
EDGE OF PAVEMENT
BUILDING
DEBRIS AREA

SOURCE: PHR & A, AUGUST 1995.

FIGURE 4-6
POSITIVE DETECTIONS OF SELECT INORGANIC ANALYTES IN SHALLOW GROUNDWATER
SITE 1
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

318715WP

LOCATION	1GW13A–01
DATE SAMPLED	02/10/96
SEMIVOLATILES (ug/L)	
PHENANTHRENE	2 J
PYRENE	2 J
DI–N–OCTYL PHTHALATE	4 J

LOCATION	1GW13A–01D
DATE SAMPLED	02/10/96
SEMIVOLATILES (ug/L)	
PHENANTHRENE	2 J

LOCATION	3GW15–01
DATE SAMPLED	02/12/96
VOLATILES (ug/L)	
1,2–DICHLOROETHENE (TOTAL)	110
TRICHLOROETHENE	83 B
SEMIVOLATILES (ug/L)	
PHENANTHRENE	2 J

LOCATION	3GW19–01
DATE SAMPLED	02/11/96
VOLATILES (ug/L)	
VINYL CHLORIDE	48
1,1–DICHLOROETHENE	4 J
1,2–DICHLOROETHENE (TOTAL)	570
TRICHLOROETHENE	860

LOCATION	3GW19A–01
DATE SAMPLED	02/11/96
VOLATILES (ug/L)	
1,2–DICHLOROETHENE (TOTAL)	24
TRICHLOROETHENE	24
TOLUENE	3 J
SEMIVOLATILES (ug/L)	
DI–N–OCTYL PHTHALATE	3 J

LOCATION	3GW08–01
DATE SAMPLED	02/11/96
VOLATILES (ug/L)	
TRICHLOROETHENE	10

LOCATION	3GW07–01
DATE SAMPLED	02/11/96
VOLATILES (ug/L)	
TRICHLOROETHENE	3 J

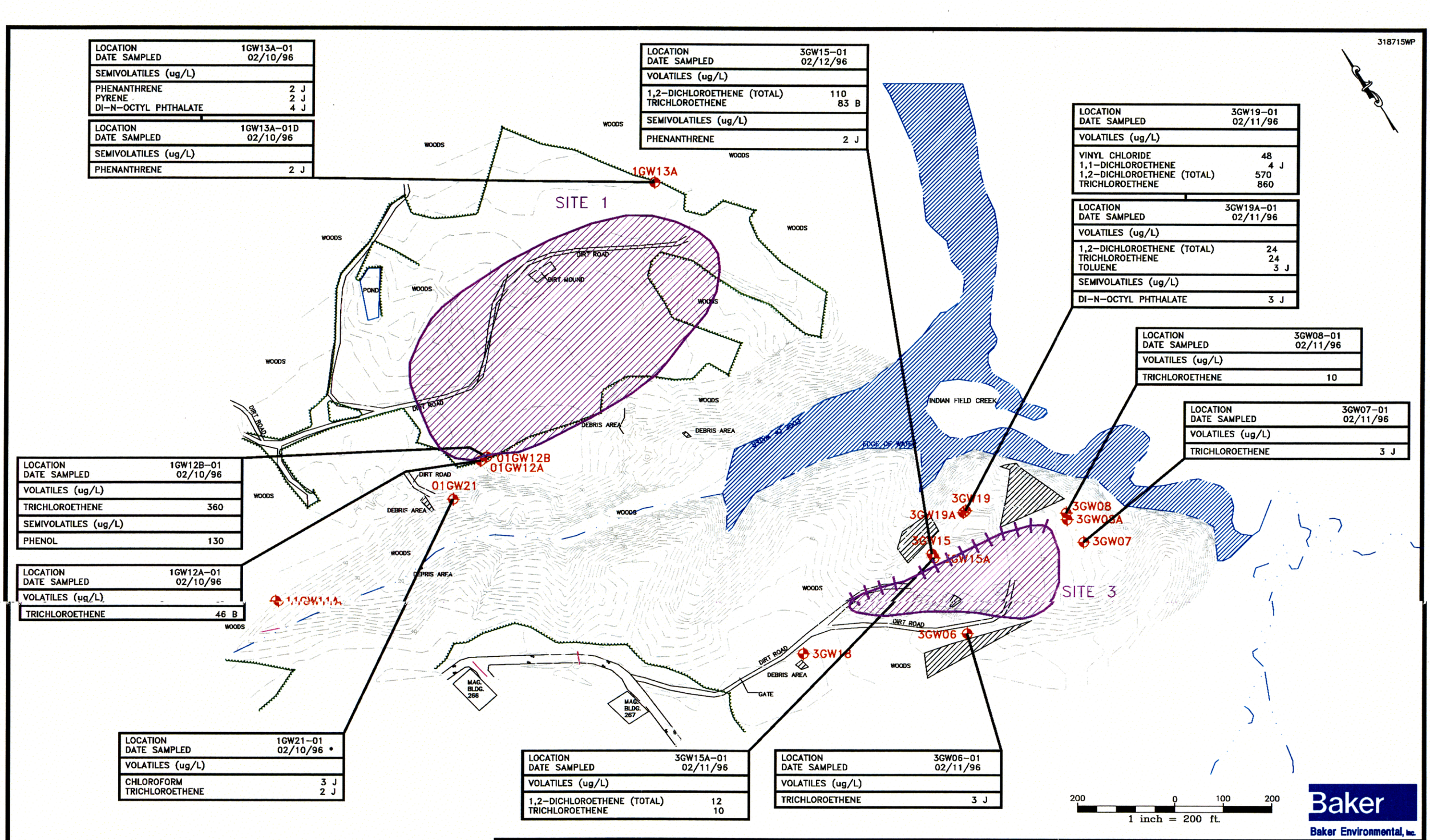
LOCATION	1GW12B–01
DATE SAMPLED	02/10/96
VOLATILES (ug/L)	
TRICHLOROETHENE	360
SEMIVOLATILES (ug/L)	
PHENOL	130

LOCATION	1GW12A–01
DATE SAMPLED	02/10/96
VOLATILES (ug/L)	
TRICHLOROETHENE	46 B

LOCATION	1GW21–01
DATE SAMPLED	02/10/96 *
VOLATILES (ug/L)	
CHLOROFORM	3 J
TRICHLOROETHENE	2 J

LOCATION	3GW15A–01
DATE SAMPLED	02/11/96
VOLATILES (ug/L)	
1,2–DICHLOROETHENE (TOTAL)	12
TRICHLOROETHENE	10

LOCATION	3GW06–01
DATE SAMPLED	02/11/96
VOLATILES (ug/L)	
TRICHLOROETHENE	3 J



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LEGEND

- 1GW17 — MONITORING WELL
- REMEDIAL INVESTIGATION SITE
- TREELINE
- EDGE OF PAVEMENT
- BUILDING
- DEBRIS AREA

SOURCE: PHR & A, AUGUST 1995.

FIGURE 4–7
POSITIVE DETECTIONS OF SELECT ORGANIC COMPOUNDS IN DEEP GROUNDWATER SITES 1 AND 3

NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

318714WP

LOCATION	1GW13A–01
DATE SAMPLED	02/10/96
TOTAL INORGANICS (ug/L)	
ALUMINUM	25900
ARSENIC	24 L
BERYLLIUM	1.1
CADMIUM	3.3
CHROMIUM	154
IRON	73400
LEAD	26.7
MANGANESE	334
VANADIUM	104

LOCATION	1GW13A–01D
DATE SAMPLED	02/10/96
TOTAL INORGANICS (ug/L)	
ALUMINUM	18100
ARSENIC	18.1 L
BERYLLIUM	2.1
CADMIUM	2.4
CHROMIUM	112
IRON	53600
LEAD	20.3
MANGANESE	253
VANADIUM	75

LOCATION	1GW13AF–01
DATE SAMPLED	02/10/96
DISSOLVED INORGANICS (ug/L)	
ARSENIC	1.4 L

LOCATION	1GW13AF–01D
DATE SAMPLED	02/10/96
DISSOLVED INORGANICS (ug/L)	
ARSENIC	1.1 L

NOTES:

1. ELEVATIONS SHOWN WERE TAKEN FROM AN ALUMINUM RIVET LOCATED IN CONCRETE HEADWALL N. OF N. RD. TO AMMO OVERHAUL. BENCH MARK NUMBER MR–23 ELEVATION=44.11'
2. HORIZONTAL INFORMATION SHOWN WAS TAKEN FROM A DRAWING TITLED "HORIZONTAL SURVEYING CONTROL POINTS INDEX" BY TALBOT AND ASSOCIATES, LTD. CODE IDENT. NO. 80091 SHEET NUMBER I–7.

LOCATION	3GW15AF–01
DATE SAMPLED	02/11/96
DISSOLVED INORGANICS (ug/L)	
MANGANESE	95.6

LOCATION	3GW15A–01
DATE SAMPLED	02/11/96
TOTAL INORGANICS (ug/L)	
IRON	2100
MANGANESE	106

LOCATION	3GW19F–01
DATE SAMPLED	02/11/96
DISSOLVED INORGANICS (ug/L)	
MANGANESE	204

LOCATION	3GW19–01
DATE SAMPLED	02/11/96
TOTAL INORGANICS (ug/L)	
ALUMINUM	32300 K
BERYLLIUM	2.3
CADMIUM	2.5 L
CHROMIUM	177
IRON	91100
LEAD	22
MANGANESE	621
VANADIUM	225

LOCATION	3GW19A–01
DATE SAMPLED	02/11/96
TOTAL INORGANICS (ug/L)	
ALUMINUM	6780 K
ARSENIC	10.6
CHROMIUM	41.6
IRON	16400
MANGANESE	119
VANADIUM	32.1

LOCATION	3GW08–01
DATE SAMPLED	02/11/96
TOTAL INORGANICS (ug/L)	
ARSENIC	9.8
IRON	6520

LOCATION	3GW08F–01
DATE SAMPLED	02/11/96
DISSOLVED INORGANICS (ug/L)	
ARSENIC	1.4
CADMIUM	2.9 K

LOCATION	3GW08A–01
DATE SAMPLED	02/12/96
TOTAL INORGANICS (ug/L)	
IRON	1740
MANGANESE	91.3

LOCATION	3GW08AF–01
DATE SAMPLED	02/12/96
DISSOLVED INORGANICS (ug/L)	
MANGANESE	88.3

LOCATION	3GW07–01
DATE SAMPLED	02/11/96
TOTAL INORGANICS (ug/L)	
ARSENIC	11.3
CHROMIUM	18.7
IRON	8830

LOCATION	3GW06–01
DATE SAMPLED	02/11/96
TOTAL INORGANICS (ug/L)	
ALUMINUM	4410 K
ARSENIC	13.6
CHROMIUM	19.9
IRON	12200
VANADIUM	26.2

LOCATION	3GW06–01D
DATE SAMPLED	02/11/96
TOTAL INORGANICS (ug/L)	
ALUMINUM	11200 K
ARSENIC	24.6
CHROMIUM	46.9
IRON	28000
MANGANESE	118
VANADIUM	54.1

LOCATION	3GW06F–01
DATE SAMPLED	02/11/96
DISSOLVED INORGANICS (ug/L)	
ARSENIC	1

LOCATION	3GW06F–01D
DATE SAMPLED	02/11/96
DISSOLVED INORGANICS (ug/L)	
ARSENIC	1.2

LOCATION	1GW12A–01
DATE SAMPLED	02/10/96
TOTAL INORGANICS (ug/L)	
ARSENIC	1.6 L

LOCATION	1GW12BF–01
DATE SAMPLED	02/10/96
DISSOLVED INORGANICS (ug/L)	
ARSENIC	1.5 L

LOCATION	1GW12B–01
DATE SAMPLED	02/10/96
TOTAL INORGANICS (ug/L)	
ALUMINUM	10200
ARSENIC	4.2 L
BERYLLIUM	0.99
CHROMIUM	27.8
IRON	24200
MANGANESE	117
VANADIUM	28.2

LOCATION	3GW18–01
DATE SAMPLED	02/11/96
TOTAL INORGANICS (ug/L)	
ARSENIC	4.8
IRON	1130

LOCATION	3GW18F–01
DATE SAMPLED	02/11/96
DISSOLVED INORGANICS (ug/L)	
ARSENIC	2.5 K

LOCATION	3GW18–01D
DATE SAMPLED	02/11/96
TOTAL INORGANICS (ug/L)	
ARSENIC	4.5
IRON	1440

LOCATION	3GW18F–01D
DATE SAMPLED	02/11/96
DISSOLVED INORGANICS (ug/L)	
ARSENIC	2.7

1GW13A
SITE 1
1SG04
1SG05
1SG01
INDIAN FIELD CREEK
1SG02
1SG03
EDGE OF WATER
1GW12B
01GW12B
01GW12A
01GW21
11GW11A
3GW18
3GW19
3GW19A
3GW08
3GW08A
3GW07
3GW15
3GW15A
SITE 3
3GW06
WOODS
DIRT ROAD
DIRT MOUND
POND
DEBRIS AREA
MAG. BLDG. 266
MAG. BLDG. 267
GATE

200 0 100 200
1 inch = 200 ft.

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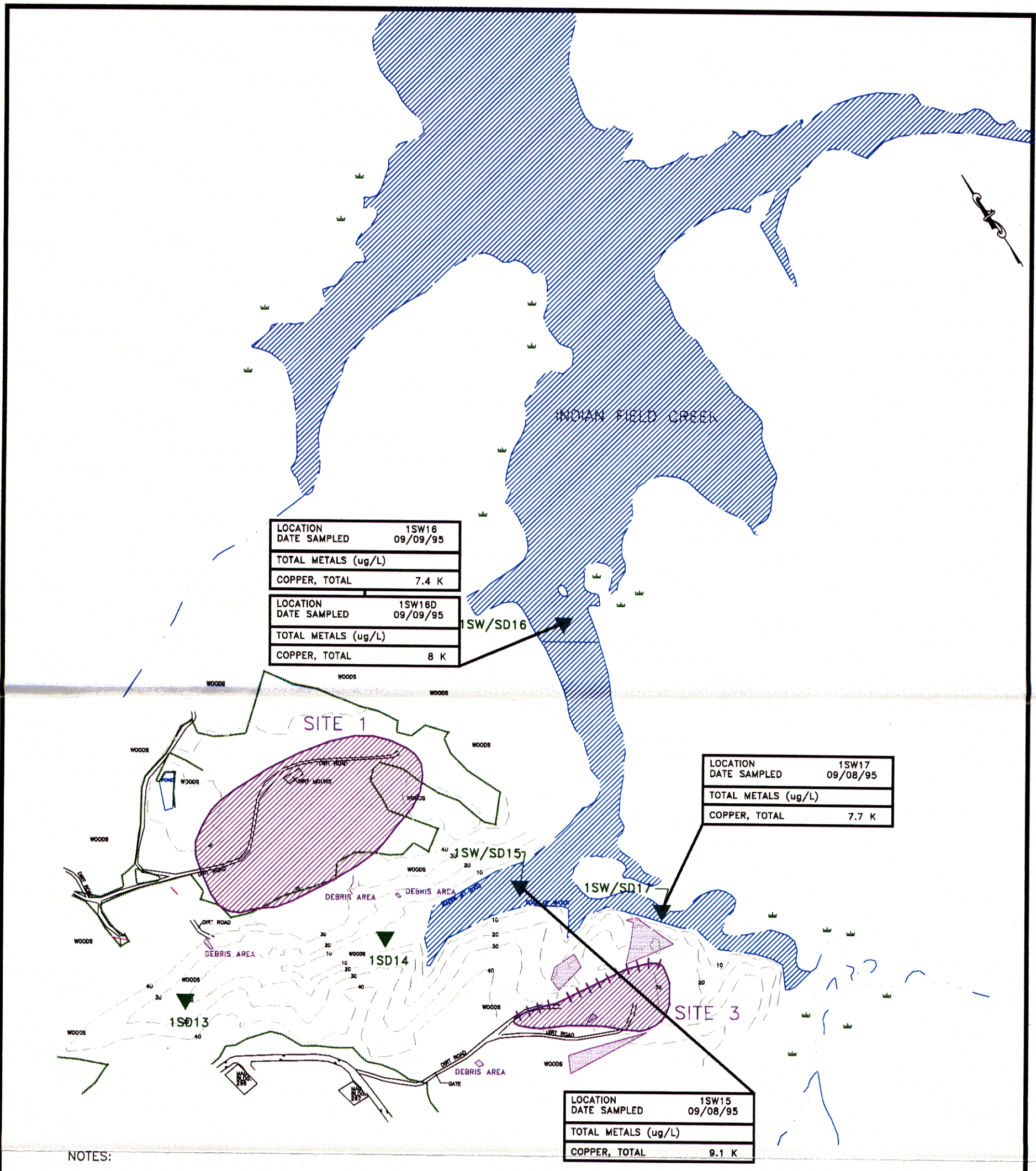
LEGEND

1GW17 MONITORING WELL
1SG01 STAFF GAUGE
REMEDIAL INVESTIGATION SITE
TREELINE
EDGE OF PAVEMENT
BUILDING
DEBRIS AREA

SOURCE: PHR & A, AUGUST 1995.

FIGURE 4–8
POSITIVE DETECTIONS OF SELECT INORGANIC ANALYTES IN DEEP GROUNDWATER SITES 1 AND 3
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA



NOTES:

1. ELEVATIONS SHOWN WERE TAKEN FROM AN ALUMINUM RIVET LOCATED IN CONCRETE HEADWALL N. OF N. RD. TO AMMO OVERHAUL. BENCH MARK NUMBER MR-23 ELEVATION=44.11'

2. HORIZONTAL INFORMATION SHOWN WAS TAKEN FROM A DRAWING TITLED "HORIZONTAL SURVEYING CONTROL POINTS INDEX" BY TALBOT AND ASSOCIATES, LTD. CODE IDENT. NO. 80091 SHEET NUMBER I-7.

300 0 150 300

1 inch = 300 ft.

318703WP

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LEGEND

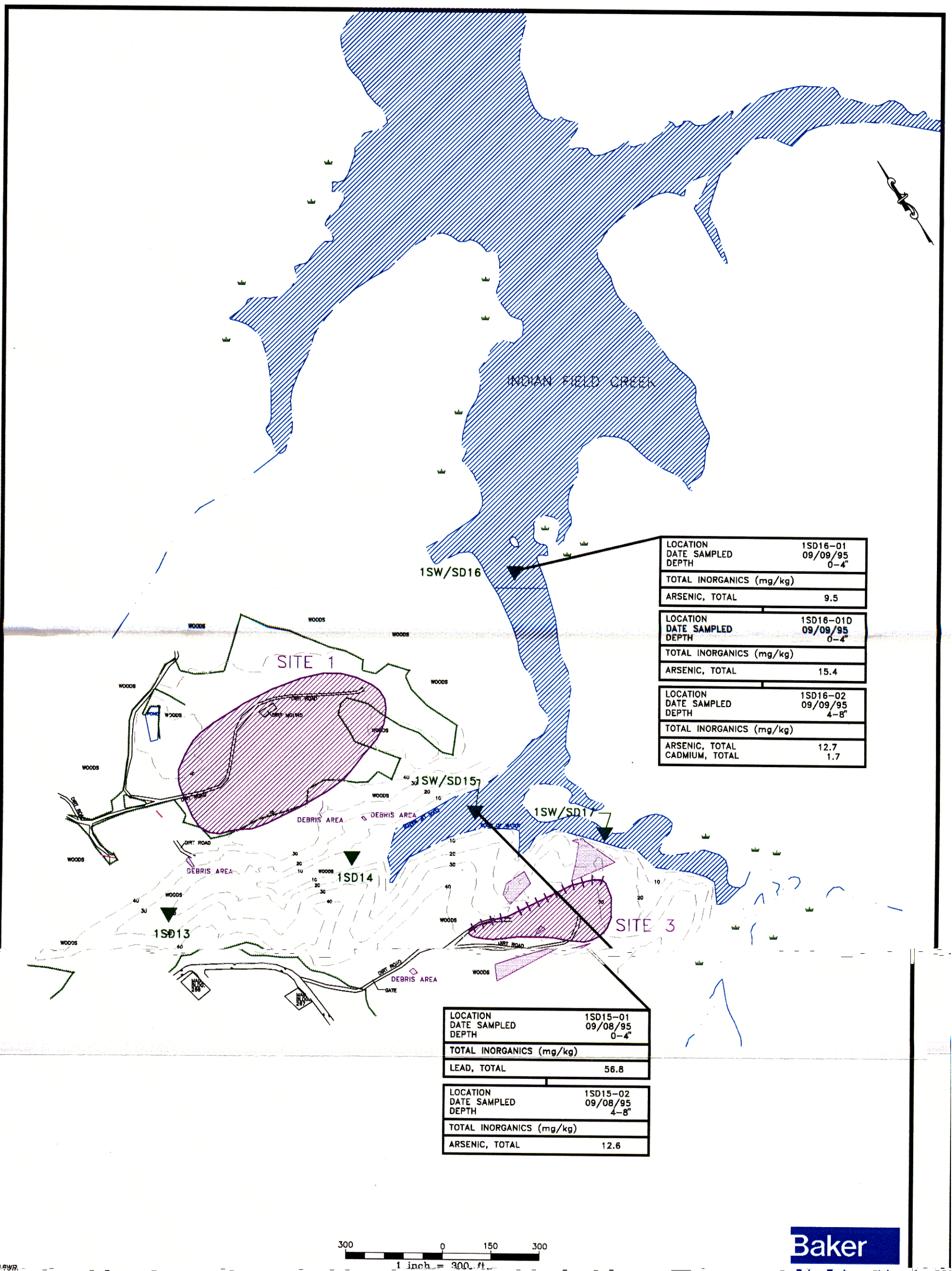
- EDGE OF WATER
- TREELINE
- EDGE OF PAVEMENT
- BUILDING
- WETLANDS
- DEBRIS AREA
- REMEDIAL INVESTIGATION SITE

1SW/SD17 - ROUND TWO RI SURFACE WATER/SEDIMENT/ BENTHIC/FISH SURVEY LOCATION

SOURCE: PHR & A, AUGUST 1995.

FIGURE 4-9
POSITIVE DETECTIONS OF SELECT INORGANIC ANALYTES IN SURFACE WATER SITES 1 AND 3

NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA



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LEGEND

- EDGE OF WATER
- TREELINE
- EDGE OF PAVEMENT
- BUILDING
- WETLANDS
- DEBRIS AREA
- REMEDIAL INVESTIGATION SITE

1SW/SD17 – ROUND TWO RI SURFACE WATER/SEDIMENT/ BENTHIC/FISH SURVEY LOCATION

SOURCE: PHR & A, AUGUST 1995.

FIGURE 4-10
POSITIVE DETECTIONS OF SELECT INORGANIC ANALYTES IN SEDIMENT (0-4") AND SUBSURFACE SEDIMENT (4-8")
SITES 1 AND 3

NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

A
NORTHEAST

A'
SOUTHWEST

1GW14
01GW18
1GW12
01GW12A
01GW12B
COLUMBIA AQUIFER
(ND)
(ND)
(104 B ug/L)
GROUND SURFACE
EROSIONAL FEATURE OF CONFINING UNIT
1GW20
CORNWALLIS CAVE CONFINING UNIT
(242 ug/L)
(360 ug/L)
B.T. 2.7
300
200
100
(46 B ug/L)
CORNWALLIS CAVE/YORKTOWN-EASTOVER AQUIFER
INDIAN FIELD CREEK
1GW04
(ND)
3GW19A
3GW19
3GW07
silty SAND
silty CLAY
clayey SILT
silty SAND
(1482 ug/L)
(3 J ug/
1000
500
100
(51 ug/L)
50

ELEVATION (FEET, MSL)
40
30
20
10
0
−10
−20

318726WP

NOTE: CONCENTRATIONS QUALIFIED WITH A "B" ARE NON-DETECT ACCORDING TO EPA REGULATIONS, BUT ARE PRESENTED ON FIGURES TO DEPICT THE MOST CONSERVATIVE SCENARIO.

FIGURE 4-11
VERTICAL EXTENT AND MIGRATION PATHWAYS OF TCE AND DCE IN GROUNDWATER SITES 1 AND 3

NAVL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

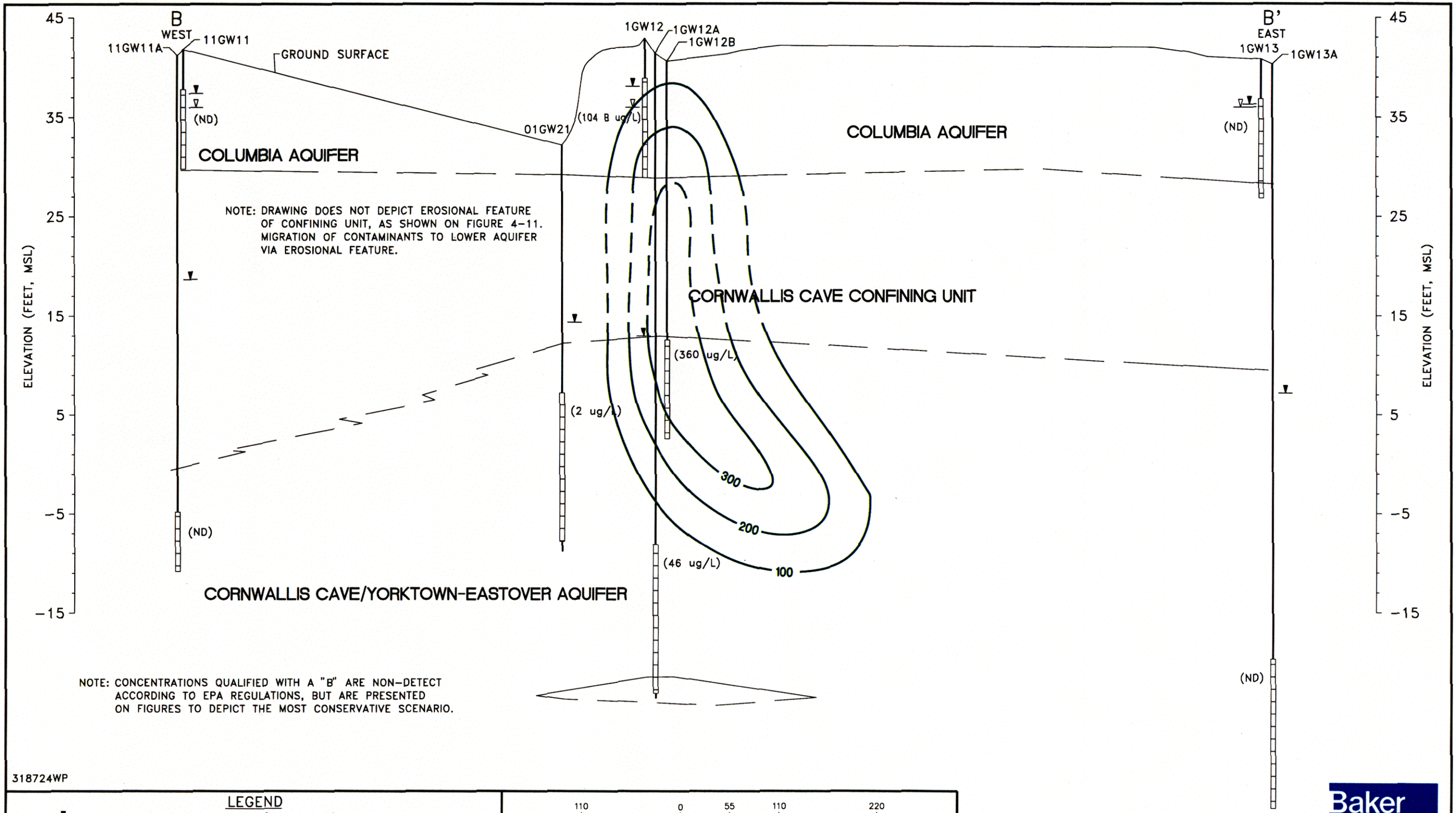
LEGEND

▽ GROUNDWATER ELEVATION
(360 ug/L) TCE AND DCE DETECTED IN GROUNDWATER
—500— TCE CONCENTRATION

150 0 75 150 300
Horizontal Scale: 1 inch = 150 ft.

10 0 5 10 20
Vertical Scale: 1 inch = 10 ft.

THE SOIL BORING INFORMATION IS CONSIDERED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT THE RESPECTIVE BORING LOCATIONS. SUBSURFACE CONDITIONS INTERPOLATED BETWEEN BORINGS ARE ESTIMATED BASED ON ACCEPTED SOIL ENGINEERING PRINCIPLES AND GEOLOGIC JUDGEMENT.



NOTE: CONCENTRATIONS QUALIFIED WITH A "B" ARE NON-DETECT ACCORDING TO EPA REGULATIONS, BUT ARE PRESENTED ON FIGURES TO DEPICT THE MOST CONSERVATIVE SCENARIO.

318724WP

LEGEND

▽	GROUNDWATER ELEVATION (35 FT. MSL)
(360 ug/L)	TCE DETECTED IN GROUNDWATER
(ND)	NOT DETECTED
300	TCE CONCENTRATION

110 0 55 110 220

Horizontal Scale: 1 inch = 110 ft.

10 0 5 10 20

Vertical Scale: 1 inch = 10 ft.

THE SOIL BORING INFORMATION IS CONSIDERED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT THE RESPECTIVE BORING LOCATIONS. SUBSURFACE CONDITIONS INTERPOLATED BETWEEN BORINGS ARE ESTIMATED BASED ON ACCEPTED SOIL ENGINEERING PRINCIPLES AND GEOLOGIC JUDGEMENT.

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FIGURE 4-12
VERTICAL EXTENT AND MIGRATION PATHWAYS OF TCE IN GROUNDWATER
SITE 1

NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

318725WP

SITE 1

SITE 3

1GW13 (ND)

1GW17 (ND)

1GW14 (ND)

1GW19 (4J)

1GW18 (ND)

1GW12 (104B)

1GW20 (242)

1GW05 (ND)

1GW04 (ND)

11GW11 (ND)

3GW19 (1482)

3GW08 (10)

3GW07 (3J)

3GW15 (110)

3GW06 (3J)

3GW18 (ND)

WOODS

DIRT ROAD

DIRT MOUND

POND

DEBRIS AREA

INDIAN FIELD CREEK

EDGE OF WATER

MAG. BLDG. 266

MAG. BLDG. 267

GATE

1,000

500

100

50

40

30

20

10

180 0 90 180

1 inch = 180 ft.

NOTE: CONCENTRATIONS QUALIFIED WITH A "B" ARE NON-DETECT ACCORDING TO EPA REGULATIONS, BUT ARE PRESENTED ON FIGURES TO DEPICT THE MOST CONSERVATIVE SCENARIO.

LEGEND

- EDGE OF WATER
- TREELINE
- EDGE OF PAVEMENT
- BUILDING
- WETLANDS
- DEBRIS AREA
- REMEDIAL INVESTIGATION SITE
- 1GW11 – MONITORING WELL LOCATION
- (110) – TOTAL VOC CONCENTRATIONS IN ug/L
- 1,000 – ESTIMATED VOC CONCENTRATION CONTOUR IN ug/L

SOURCE: PHR & A, AUGUST 1995.

FIGURE 4-13

HORIZONTAL EXTENT OF TOTAL VOCs
COLUMBIA AQUIFER (SITE 1) AND THE C
CAVE/YORKTOWN-EASTOVER AQUIFER

NAVAL WEAPONS STATION YORKT
YORKTOWN, VIRGINIA

Baker Environmental, Inc.

s IN THE
ORNWALLIS
(SITE 3)
OWN

5.0 CONTAMINANT FATE AND TRANSPORT

This section contains a discussion on the various physical and chemical properties, potential mobility, and persistence of contaminants detected at Sites 1 and 3 that could potentially determine

contamination at Sites 1 and 3 was presented in Section 4.0.

Of the environmental media evaluated at Sites 1 and 3, groundwater has experienced the most impact from site operations. Accordingly, the majority of this section will focus on contaminant fate and transport through the groundwater pathway.

5.1 Chemical and Physical Properties

The potential for a contaminant to migrate and persist in environmental media is an important factor in evaluating risk to human health and the environment. The environmental mobility of a chemical is influenced by its physical and chemical properties, the physical characteristics of the site, and the site chemistry. This section evaluates the properties of the contaminants detected at Sites 1 and 3 with emphasis on potential environmental mobility and persistence.

Migration of Contaminants (organic and inorganic) through groundwater is influenced by chemical and physical reactions between the contaminant, groundwater and the solid media through which it flows (the aquifer). Table 5-1 presents the physical and chemical properties that determine a contaminant's inherent environmental mobility and fate for the Contaminants of Potential Concern (COPCs) detected at the sites. These properties include:

- Specific gravity
- Vapor pressure
- Water solubility
- Octanol/water partition coefficient
- Bioconcentration factor
- Soil/sediment adsorption coefficient

- Henry's Law constant
- Mobility index

Inorganic groundwater COPCs (Arsenic, Cadmium, Manganese and Zinc) do not exhibit an apparent source of discernable pattern at these sites. As such, the following discussion will focus on organic contaminants and the properties influencing their mobility and fate. A discussion of the environmental significance of each property follows.

Specific gravity is the ratio of a given column of pure chemical at a specified temperature to the weight of the same volume of water at a given temperature. Its primary use is to determine whether a contaminant will have a tendency to float or sink (as an immiscible liquid) in water if it exceeds its corresponding water solubility.

Vapor pressure provides an indication of the rate at which a chemical may volatilize. It is of primary significance at environmental interfaces such as surface soil/air and surface water/air. Volatilization is not as important when evaluating groundwater and subsurface soil as it is when evaluating surface soil or surface water.

Vapor pressures for monocyclic aromatics and chlorinated volatiles such as TCE are generally higher than vapor pressures for PAHs. Contaminants with high vapor pressures will enter the atmosphere at a quicker rate than the contaminants with lower vapor pressures.

The rate at which a contaminant is leached from soil by infiltrating precipitation can be proportional to its water solubility. More soluble contaminants are usually more readily leached than less soluble contaminants. The water solubilities indicate, for example, that the volatile organic contaminants including monocyclic aromatics are usually several order-of-magnitudes more soluble than pesticides.

The octanol/water partition coefficient (K_{ow}) is a measure of the equilibrium partitioning of contaminants between octanol and water. A linear relationship between octanol/water partition coefficient and the uptake of chemicals by fatty tissues of animal and human receptors (the bioconcentration factor - BCF) has been established (Lyman et al., 1982). The coefficient also is

useful in characterizing the sorption of compounds by organic soil where experimental values are not available.

The organic carbon adsorption coefficient (K_{OC}) indicates the tendency of a chemical to adhere to soil particles of organic carbon. Contaminants with high soil/sediment adsorption coefficients generally have low water solubilities and vise versa. For example, contaminants such as pesticides are relatively immobile in the environment and are preferentially bound to the soil. The compounds are not subject to aqueous transport to the extent of compounds with high water solubilities. Erosional properties of surface soil may, however, enhance the mobility of these bound soil contaminants.

Both vapor pressure and water solubility are of use in determining volatilization from surface water bodies and from groundwater. These two parameters can be used to estimate an equilibrium concentration of a contaminant in the water phase and in the air directly above the water. This can be expressed as Henry's Law Constant.

A quantitative assessment of mobility has been developed that uses water solubility (S), vapor pressure (VP), and organic carbon partition coefficient (K_{OC}) (Laskowski, et al., 1983). This value is referred to as the Mobility Index (MI). It is defined as:

$$MI = \log((S*VP)/K_{OC})$$

A scale to evaluate MI is presented by Ford and Gurba (1984) below:

Relative MI	Mobility of Contaminants Detected at Sites 1 & 3
>5	Extremely mobile
0 to 5	Very mobile
-5 to 0	Slightly mobile
-10 to -5	Immobile
<-10	Very immobile

Relative MI values and mobility descriptions are included on Table 5-1. Similar mobility descriptions are presented in Roy and Griffin (1985).

5.2 Contaminant Transport Pathways

Based on the evaluation of existing conditions at Sites 1 and 3 the following general potential contaminant transport pathways have been identified:

- Off-site atmospheric deposition of windblown dust
- Surface soil runoff
- Sediment migration
- Leaching of sediment contaminants to surface water
- Migration of contaminants in surface water
- Leaching of soil contaminants to groundwater
- Migration of groundwater contaminants offsite
- Groundwater discharge to surface water body

Contaminants released to the environment may undergo the following during transportation:

- Physical transformations: volatilization, precipitation
- Chemical transformations: photolysis, hydrolysis, oxidation, reduction
- Biological transformation: biodegradation
- Accumulation in one or more media

The behavior of relevant contaminant groups (VOCs, SVOCs, etc.) in each transport pathway, under these conditions is outlined in Section 5.3. The following paragraphs describe the transport pathways listed above. A schematic diagram illustrating migration pathways is presented in Figure 5-1.

5.2.1 Off-Site Atmospheric Deposition of Windblown Dust

Wind can act as a contaminant transport agent by eroding exposed soil and exposed sediment and blowing it off site. This is influenced by wind velocity, the grain size/density of the soil/sediment particles, and the amount of vegetative cover over the soil or sediment.

Most of the study area for Site 1 and Site 3 is covered by grass, shrubs and tall trees. This would limit potential airborne migration of site contaminants. During the investigation of Sites 1 and 3, blowing dust was not noticeable and there was no vehicle traffic on site. However, off-site deposition of dust may occur if the excavation/removal of buried debris or any activities that might change future land use at Sites 1 and 3.

5.2.2 Surface Soil Runoff

Water can erode exposed soil and sediment particles during precipitation events. This is influenced by site topography, the amount of precipitation, soil/sediment particle size/density and cohesion, and vegetative cover.

Sites 1 and 3 are separated by a drainageway that makes up a tributary to Indian Field Creek. The headwaters and main channel of Indian Field Creek are located along the eastern boundaries of both sites. The slope of the topography is fairly steep here, ranging from approximately 40 ft. msl at the sites to 5 ft. msl at Indian Field Creek. Surface water runoff of leachate or potentially contaminated soil from this site is expected, but may be limited by the heavy vegetative growth in this area.

5.2.3 Sediment Migration

Sediment can be transported mechanically through the drainage ditches by surface water erosion. This is influenced by drainage ditch slope, rate of surface water flow, sediment size/density and particle cohesion, and vegetative cover. Sediment analytical results indicates that sediment has not been impacted by site operations.

5.2.4 Leaching of Sediment Contaminants to Surface Water

When in contact with surface water, contaminants attached to sediment particles can desorb from the sediment particle and partition into the surface water. Hydrophobic contaminants present in surface water can also be removed from the water column by sediment. An equilibrium between sediment concentrations and surface water concentrations may be established in an aquatic system over time. The rate at which equilibrium is reached is influenced by the physical and chemical properties of the contaminant, the physical and chemical properties of the sediment particle, and the physical and chemical properties of the surface water.

Surface water and sediment sample analytical results indicate that this is not an active contaminant migration pathway at these sites.

5.2.5 Migration of Contaminants in Surface Water

Contaminants leaching from soil to surface water can migrate as dissolved constituents in surface water in the direction of surface water flow. Three general processes govern the migration of dissolved contaminants caused by the flow of water: (1) movement caused by the flow of surface water, (2) movement caused by irregular mixing of water, and (3) chemical mechanisms occurring during the movement of surface water. As stated earlier, contaminants can disassociate from the sediment particle into surface water and migrate in one of the aforementioned methods. These processes are discussed in more detail in Subsection 5.2.7.

Migration pathways associated with surface water and sediment from the headwater tributary to Indian Field Creek include the transport of contaminants via surface water movement, adsorption/desorption process from surface water to sediment, and discharge to or from groundwater. The adsorption/desorption process, from surface water to sediment, can create a contaminant "sink." Adsorption/desorption mechanisms also involve complex chemical and biochemical reactions. For example, as chemicals are desorbed from sediment, they may be available for uptake by receptors from the water column.

Surface water analytical results indicate that this is not an active contaminant migration pathway at these sites.

5.2.6 Leaching of Soil Contaminants to Groundwater

Contaminants in the site soil can leach and migrate vertically to the groundwater with infiltrating precipitation. This is influenced by the physical and chemical properties of the soil, the physical and chemical properties of the contaminant, the amount of precipitation, and the depth to the water table.

VOCs were detected in groundwater at both sites. Although analytical results indicate that there is currently no apparent source of VOC contamination in soil from these sites, it is likely that the groundwater contaminants have leached from or through these soils.

5.2.7 Migration of Groundwater Contaminants Offsite

Organic non-aqueous liquid contaminants that reach the groundwater zone are either dissolved in water or are organic liquid phases that may be immiscible in water. The subsurface transport of immiscible organic liquids is governed by a set of factors different from those of dissolved contaminants. Analytical results and field observations indicate that organic groundwater contaminants at Sites 1 and 3 are dissolved in groundwater. The following paragraphs are limited to a discussion of migration of dissolved groundwater contaminants.

Three general processes govern the migration of dissolved contaminants caused by the flow of groundwater: (1) advection, movement caused by flow of groundwater; (2) dispersion, movement caused by irregular mixing of waters during advection; and (3) chemical mechanisms which occur during advection.

5.2.7.1 Advection

Advection is the process which most strongly influences the migration of dissolved organic solutes. Groundwater generally flows from regions of the subsurface where the water level is high to regions where the water level is low. Hydraulic gradient is the term used to describe the magnitude of this

force or the relative slope of the water table. In general, the gradient usually follows the topography for uniform sandy aquifers (unconfined or water table aquifers) which are commonly found in coastal regions. The average flow velocity of deep groundwater at Sites 1 and 3 as calculated in Section 3.3.1 is less than 1 ft/day. At this rate, groundwater located at the center of Sites 1 or 3 would take approximately one year to migrate to Indian Field Creek. This travel time assumes that no alteration of contaminants would take place in the saturated zone through absorption - desorption processes.

5.2.7.2 Dispersion

Dispersion results from two basic processes, molecular diffusion and mechanical mixing. The kinetic activity of dissolved solutes results in diffusion of solutes from a zone of high concentration to a lower concentration. Dispersion and spreading during transport results in the dilution of contaminants (maximum concentration of contaminant decreases with distance from the plume). For simple hydrogeologic systems, the spreading is estimated to be proportional to the flow rate. Furthermore, dispersion in the direction transverse (perpendicular) to the flow also occurs. In the absence of detailed studies to determine dispersive characteristics at Sites 1 and 3, longitudinal and transverse dispersion must be estimated based on similar hydrogeological systems (Mackay, et al., 1985).

5.2.7.3 Chemical Mechanisms

Some dissolved contaminants may interact with the aquifer solids (i.e., subsurface soil) encountered along the flow path through adsorption, partitioning, ion exchange, and other processes. The interactions result in the contaminant's distribution between the aqueous phase and the aquifer solids, diminution of concentrations in the aqueous phase, and retardation of the movement of the contaminant relative to groundwater flow. The higher the fraction of the contaminant sorbed, the more retarded its transport (Mackay, et al., 1985). The sorption of certain halogenated organic solvents is affected by hydrophobility (antipathy for dissolving in water) and the fraction of solid organic matter in the aquifer solids (organic carbon content).

Organic contaminants can be transformed into other organic compounds by a complex set of chemical and biological mechanisms. The principle classes of chemical reactions that can affect organic contaminants in water are hydrolysis and oxidation. However, it is believed that most chemical reactions occurring in the groundwater zone are likely to be slow compared with transformations mediated by microorganisms. Certain organic groundwater contaminants can be biologically transformed by microorganisms attached to solid surfaces within the aquifer. Factors which affect the rates of biotransformation of organic compounds include: water temperature and pH, the number of species of microorganisms present, the concentration of substrate, presence of microbial toxicants and nutrients, and the availability of electron acceptors (Mackey, et al., 1985). The interaction of non-ionic organic compounds with solid phases can be used to predict the fate of the contaminant. Sorptive binding is a function of the organic content of the sorbent. Sorption of non-ionic organic compounds can be attributed to an active fraction of the soil organic matter. The uptake of neutral organics by soil results from their partitioning and a function of the aqueous solubility of the chemical and its liquid-liquid (e.g., octanol-water) partition coefficient (Chiou, 1979). Organic matrices in natural systems that have varying origins, degrees of humification, and degrees of association with inorganic matrices exhibit dissimilarities in their ability to sorb non-ionic organic contaminants.

Soil also contains surface-active mineral and humic constituents that are involved in reactions that affect inorganic contaminant retention. The surfaces of fine-grained soil particles are very active chemically; surface sites are negatively or positively charged or they are electronically neutral. Oppositely charged metallic counterions from solutions in soil are attracted to these charged surfaces. The relative proportions of ions attracted to these various sites depend on the degree of acidity or alkalinity of the soil, on its mineralogical composition, and on its content of organic matter. The extent of adsorption depends on either the respective charges on the adsorbing surface or the metallic cation. In addition to these adsorption reactions, precipitation of new mineral phases also may occur if the chemical composition of the soil solution becomes supersaturated with respect to the insoluble precipitates. Of the probable precipitates, the most important of these phases are hydroxides, carbonates, and sulfides. The precipitation of hydroxide minerals is important for metals such as iron and aluminum, the precipitation of carbonate minerals is significant for calcium and barium, and the precipitation of sulfide minerals dominates the soil chemistry of zinc, cadmium, and mercury. A number of precipitates may form if metals are added to soil; the concentration of

metal solution will be controlled, at equilibrium, by the solid phase that results in the lowest value of the activity of the metallic ion in solution.

5.3 Fate and Transport Summary

The following summarize the contaminant fate and transport data for some potential COPCs at Sites 1 and 3.

5.3.1 Volatile Organic Compounds

VOC COPCs were detected in groundwater at Sites 1 and 3. These compounds are all classified as very mobile (Table 5-11). Analytical results indicate that there has been migration of these comtaminants, groundwater degredation appears to be limited to the southwest portion of Site 1 and the northeast portion of Site 3.

5.3.2 Semivolatile Organic Compounds

SVOC COPCs were detected during investigations at Sites 1 and 3 in soils and groundwater. The majority of these SVOCs are immobile to very immobile in environmental media (Table 5-1). Low water solubilities and high K_{ow} and K_{oc} values indicate a strong tendency to adsorb to soil. Their mobility indices indicate that they are relatively immobile from a physical-chemical standpoint.

5.3.3 Nitramine Compounds

Nitramine COPCs were not identified at Sites 1 and/or 3.

5.3.4 Inorganics

Inorganics were detected during investigations at Sites 1 and 3 in all media. Inorganics can be found as solids at ambient temperature and pressure in soil at the sites. Inorganic ions exist in pure solutions as hydrated ions. Groundwater, as opposed to a pure solution, is a highly complex chemical system that is heavily influenced by the mineralogy of the substrate. Factors affecting the

transport of inorganics in saturated soil are interactive and far more complex and numerous than those affecting the transport of organic contaminants.

The most complicated pathway for inorganic contaminants is migration in subsurface soil and groundwater, where oxidation-reduction potential (Eh) and pH play critical roles. Table 5-2 presents an assessment of relative inorganic environmental mobilities as a function of Eh and pH. [This table is based on data collected during previous investigations conducted at the Station and is considered to be representative of conditions at Sites 1 and 3.] Soil at WPNSTA Yorktown is relatively neutral to slightly acidic; therefore, inorganics in the subsurface soil should be relatively immobile.

Transport of inorganic species in groundwater is mainly a function of the inorganic's solubility in solution under the chemical conditions of the soil-solution matrix. The inorganic must be dissolved (i.e., in solution) for leaching and transport by advection with the groundwater to occur. Generally, dynamic and reversible processes control solubility and transport of the dissolved metal ions. Such process include precipitation/dissolution, adsorption/desorption, and ion exchange.

Inorganics could be sorbed onto colloidal materials, theoretically increasing their inherent mobility in saturated porous media. It is important to note, however, that most colloids themselves are not mobile in most soil\water systems.

5.4 References

Chiou, C. T., L. J. Peters, and V. H. Freed. 1979. "A Physical Concept of Soil-Water Equilibria for Non-Ionic Organic Compounds." Science. Vol. 206, pp. 831-832.

Ford and Gurba. 1984. Methods of Determining Relative Contaminant Mobilities and Migration Pathways Using Physical-Chemical Data.

Laskowski, D.A., Goring, C.A., McCall, P.J., and Swann, R.L. 1983. "Terrestrial Environment in Environmental Risk Analysis for Chemicals," Environmental Risk Analysis for Chemicals, R.A. Conways, ed., Van Nostrand Reinhold Co., New York, New York.

Lyman, W. J., W. F. Rechl, and D. H. Rosenblatt. 1982. Handbook of Chemical Property Estimation Methods. McGraw-Hill, Inc., New York.

Mackey, P. M., P. V. Roberts, and J. A. Cherry. 1985. "Transport of Organic Contaminants in Groundwater." Environmental Science and Technology. Vol. 19, No. 5, pp. 384-392.

Roberts, W.C., and W.R. Hartley. 1992. Drinking Water Health and Advisory: Munitions. Lewis Publishers, Boca Raton, Florida.

Roy, W. R. and R. A. Griffin. 1985. "Mobility of Organic Solvents in Water-Saturated Soil Materials." Environmental Geology and Water Sciences. Vol. 7, No. 4, pp.241-247.

TABLES

TABLE 5-1

PHYSICAL AND CHEMICAL PROPERTIES OF THE ORGANIC COPCs
SITES 1 and 3
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Chemical	Specific Gravity (g/cm^3)	Vapor Pressure (mmHg)	Water Solubility (mg/L)	Octanol/ Water Coefficient (log K_{ow})	Sediment Partition Coefficient (log K_{oc})	Henry's Law Constant ($atm\text{-}m^3/mole$)	Mobility Index	Mobility Description
Volatiles:								
1,1-Dichloroethene	1.218	500	400	1.48	2.26	2.10E-02	3.0	Very Mobile
Trichloroethene	1.460	60	1100	2.29	2.09	9.10E-03	2.7	Very Mobile
Vinyl Chloride	0.912	2660	1100	0.60	1.91	5.60E-02	4.6	Very Mobile
Carbon Disulfide	1.263	260	2300	1.84	2.08	1.23E-02	3.7	Very Mobile
Trans-1,2-Dichloroethene	1.260	200	600	1.48	2.17	5.32E-03	2.9	Very Mobile
Cis-1,2-Dichloroethene	1.260	200	600	1.48	2.17	3.84E-01	2.9	Very Mobile
Semivolatiles:								
Benzo(a)Anthracene	1.274	5.00E-09	0.014	5.61	5.34	1.00E-06	-15.5	Very Immobile
Benzo(a)Pyrene	1.351	5.00E-09	0.0038	6.04	5.72	4.90E-07	-16.4	Very Immobile
Carbazole	--	--	--	--	--	--	--	--
Pentachlrophenol	1.978	1.7E-4	5	5.01	2.95	3.4E-06	-6	Low
Nitrobenzene	--	1.50E-01	1900	1.87	1.56	1.31E-05	-0.1	Slightly Mobile
Dibenzo(a,h)anthracene	--	1.00E-10	0.0005	6.86	6.38	7.33E-09	-19.7	Very Immobile
Indeno(1,2,3-cd)Pyrene	--	1.00E-10	0.0034	6.30	5.87	2.96E-20	-18.3	Very Immobile

TABLE 5-2

RELATIVE MOBILITIES OF INORGANICS AS A FUNCTION OF ENVIRONMENTAL CONDITIONS (Eh, pH)
SITES 1 and 3
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

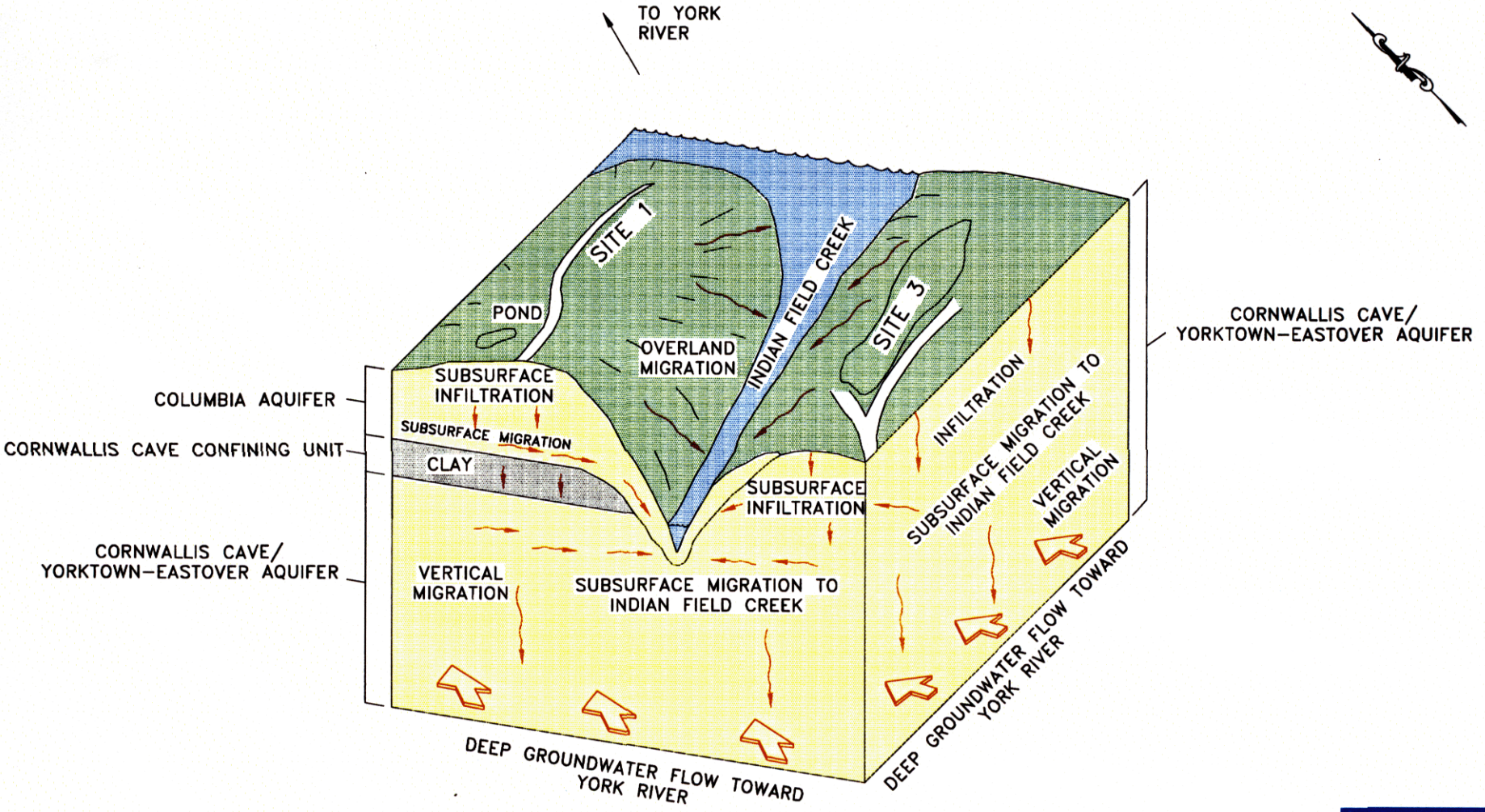
Relative Mobility	Environmental Conditions			
	Oxidizing	Acidic	Neutral/Alkaline	Reducing
Very High			Se	
High	Se, Zn	Se, Zn, Cu, Ni, Hg, Ag		
Medium	Cu, Ni, Hg, Ag, As, Cd	As, Cd	As, Cd	
Low	Pb, Ba, Se	Pb, Ba, Be	Pb, Ba, Be	
Very Low	Fe, Cr	Cr	Cr, Zn, Cu, Ni, Hg, Ag	Cr, Se, Zn, Cu, Ni, Hg, Pb, Ba, Be, Ag

Notes:

As = Arsenic
Ag = Silver
Ba = Barium
Be = Beryllium
Cd = Cadmium
Cr = Chromium
Cu = Copper
Fe = Iron
Hg = Mercury
Ni = Nickel
Pb = Lead
Se = Selenium
Zn = Zinc

Source: Swartzbaugh, et al. "Remediating Sites Contaminated with Heavy Metals." Hazardous Materials Control, November/December 1992.

FIGURES



Baker

Baker Environmental, Inc.

FIGURE 5–1
SCHEMATIC SITE MODEL
SITES 1 AND 3

NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

N.T.S.

318722WP

00998D07Y

6.0 HUMAN HEALTH RISK ASSESSMENT

A baseline human health risk assessment (RA) was performed as part of the RI/FS for Sites 1 and 3 at WPNSTA Yorktown, to evaluate the potential risks associated with exposure to environmental media resulting from existing conditions at the site if no additional remedial action is undertaken. The baseline RA considers the most likely routes of potential human exposure for both current and future risk scenarios. The baseline RA was conducted in accordance with the Risk Assessment Guidance for Superfund (RAGS), Part A, Human Health Evaluation Manual (USEPA, 1989b), and the most recent updates. A complete discussion of the previous investigations and history of Sites 1 and 3 is included in Section 1.0.

This section describes the human health RA based on evaluation of the data collected for the Round Two Remedial Investigation (RI) for Sites 1 and 3. Round Two data was used in the baseline risk assessment since it was considered more complete and representative of current site conditions. Round One data was excluded due to the fact that it was collected in 1992, and surface soil samples were collected from the 0-2 feet depth interval. This is inconsistent with what is used in a baseline RA (i.e., 0-6 inch depth interval).

After the Round Two investigation, a "hot spot" area was identified in the surface soil at Site 3. Very high concentrations of PAHs were detected in this area. Confirmatory surface soil samples and one subsurface soil sample were collected within the "hot spot" area and included in this RA. It should be noted that a removal action is planned for this "hot spot" area in the soils at Site 3. The RA evaluates potential surface soil exposures prior to and after "hot spot" removal as current and future scenarios.

The baseline RA is comprised of nine sections; Section 6.1 presents the selection of COPCs. Sections 6.2 and 6.3 present the Exposure Assessment and Toxicity Assessment, respectively. The risk characterization is presented in Section 6.4. Section 6.5 presents sources of uncertainty inherent in the estimation of inferential potential human health effects. A summary of the baseline RA is provided in Section 6.6. Section 6.7 presents the references.

6.1 Identification of Chemicals of Potential Concern

The selection of COPCs was based on the information provided in the USEPA Region III Technical Guidance on Selecting Exposure Routes and Contaminants of Concern, by Risk-Based Screening (SCCRBS), dated January 1993 (USEPA, 1993a) and USEPA's Risk Assessment Guidance for Superfund (RAGS), Volume I. Human Health Evaluation Manual (Part A), Interim Final, December 1989 (USEPA, 1989b). COPC selection was completed for each environmental medium and area of concern using analytical data obtained during this RI.

A discussion of laboratory analytical results and nature and extent of constituent contamination was presented in Section 4.0 of this report. Chemicals detected in environmental media sampled during the RI were re-evaluated in this section to select COPCs for quantitative evaluation in the baseline RA. Chemicals selected as COPCs that could not be quantitatively evaluated, such as carbazole, are discussed in the uncertainties section (Section 6.5) of the baseline RA.

6.1.1 COPC Selection Criteria

The primary criterion used in selecting a chemical as a COPC at Sites 1 and 3 included comparing the maximum detected sample concentration to the USEPA Region III Chemicals of Concern (COC) Screening Table (USEPA, 1994a), in accordance with USEPA Region III SCCRBS guidance (USEPA, 1993a). The COC screening values are updated to reflect changing toxicity criteria (since 1994), as will be discussed in subsequent paragraphs.

In conjunction with concentration comparisons to the USEPA Region III COC screening table (COC values), a comparison to concentrations detected in field and laboratory blanks collected from Sites 1 and 3 was also conducted, to ensure that only site-related contaminants are evaluated in the quantitative estimation of human health effects (refer to Table 6-1). Furthermore, those constituents generally considered to be essential nutrients (which have relatively low toxicity) were not evaluated in this baseline RA.

The prevalence of a chemical detected in a given environmental medium, as well as the history of site-related activities are other important criteria applied in selecting COPCs at Sites 1 and 3. Therefore, in conjunction with concentration comparisons to USEPA Region III COC Screening

Concentrations (COC values) and evaluations of chemical prevalence, site history, and the assessment of essential nutrients, comparisons of groundwater, surface water, and sediment to available Commonwealth and Federal standards and criteria were conducted to determine whether chemicals eliminated by a direct comparison to COC values should be re-included as COPCs. Each of the aforementioned criteria are discussed in the paragraphs that follow.

USEPA Region III COC Screening Concentrations - Risk-Based COC Screening Concentrations (COC screening concentrations) were derived by USEPA, Region III in January of 1993 and provided in tabular format to support selection of COPCs and address two major limitations in the COPC selection process presented in RAGS. First, using COC screening concentrations prioritizes chemical toxicity and focuses the risk assessment on those COPCs and potential exposure routes. Second, using the COC screening concentrations provides an absolute comparison of potential risks associated with the presence of a COPC in a given medium.

COC screening concentrations were derived using conservative USEPA promulgated default values and the most recent toxicological criteria available. COC screening concentrations for potentially carcinogenic and noncarcinogenic chemicals were individually derived based on a target incremental lifetime cancer risk (ICR) of 1×10^{-06} and a target hazard quotient (HQ) of 0.1, respectively. For potential carcinogens, the toxicity criteria applicable to the derivation of COC screening concentrations are chronic oral and inhalation cancer slope factors; for noncarcinogens, they are oral and inhalation reference doses. These toxicity criteria are subject to change as more updated information and results from the most recent toxicological/epidemiological studies become available. These changes, as will be discussed further in Section 6.3, are reported in USEPA's Integrated Risk Information System (IRIS), as well as other available sources. Therefore, the use of toxicity criteria in the derivation of COC screening concentrations requires that the screening concentrations be updated periodically to reflect changes in the toxicity criteria.

In March of 1994, the USEPA Region III published a second COC Screening Table (e.g., COC values) which was also based on an ICR of 1×10^{-06} and a target HQ of 0.1. Subsequent publications of the table (i.e., Risk-Based Concentrations [RBCs]) have included an ICR of 1×10^{-06} but an HQ of 1.0, rather than 0.1. However, since the RBCs are derived using similar equations and USEPA promulgated default exposure assumptions that were used to derive the original set of COC screening concentrations (USEPA, 1993a) and COC values (USEPA, 1994a), the COC values can

be updated from these tables by using the carcinogenic RBCs issued quarterly by USEPA Region III and dividing the accompanying noncarcinogenic RBCs by a factor of 10 for those constituents not included in the original COC value screening table. An updated set of COC values can, therefore, be obtained each time the RBC Tables are updated. The COC values used in this baseline RA were derived from the RBC values issued by the USEPA Region III on October 20, 1995 (USEPA, 1996b).

Sediment Screening Values - At present, promulgated sediment COC values or quality criteria do not exist to protect human health. However, sediment screening values (SSVs) have been published (Long, et al., 1995) for evaluating the potential for chemical constituents in sediment to cause adverse biological effects. This screening method was developed through evaluation of biological effects data for aquatic (marine and freshwater) organisms that were obtained through equilibrium partitioning calculations, spiked-sediment bioassays, and concurrent biological and chemical field surveys. For each constituent having sufficient data available, the concentrations causing adverse biological effects were arrayed and the lower tenth percentile (called an Effects Range-Low, or ER-L) and the median (called an Effects Range-Median, or ER-M) were determined. If contaminant concentrations are above the ER-M, adverse effects on the biota are considered probable.

According to USEPA Region III, exceedences of the ER-M would constitute a chemical's retention as a COPC. Therefore, constituents detected in the sediment at Sites 1 and 3 were compared to the SSV ER-Ls and ER-Ms to determine if any criteria were exceeded.

Blank Concentrations - If a chemical is detected in both the environmental sample and a blank sample, it may not be retained as a COPC in accordance with RAGS depending on the concentration of the chemical in the media. Therefore, blank data were compared with results from environmental samples. If the blanks contained detectable results for common laboratory contaminants (i.e., acetone, 2-butanone, methylene, chloride, toluene, and phthalate esters), environmental sample results were considered as positive results only if they exceed 10 times the maximum amount detected in the associated blank. If the chemical detected in the blank(s) is not a common laboratory contaminant, environmental sample results were considered as positive results only if they exceeded five times the maximum amount detected in the associated blank(s). Furthermore, the elimination of an environmental sample result would directly correlate to a reduction in the prevalence of the contaminant in that media.

When assessing soil and sediment concentrations, the Contract Required Quantitation Limits (CRQLs) and percent moisture are accounted for in order to correlate solid and aqueous quantitation limits. For example, when assessing semivolatile, pesticide, PCB, and nitramine contaminants the CRQL for solid samples is 33 to 66 times (depending on the contaminant) that of the aqueous samples; this correction is not necessary for the evaluation of volatile COPCs. Therefore, in order to assess contaminant levels in solid samples using an aqueous blank concentration, the maximum concentration was multiplied by 5 or 10 (noncommon or common laboratory contaminants, respectively) and then multiplied by 33 to correct for the variance in the CRQL. Accounting for multipliers greater than 33 or the percent moisture was not conducted for this evaluation. Associated blanks for Sites 1 and 3 included: field blanks, trip blanks, and rinsate blanks. Table 6-1 provides a summary of the maximum detected blank data and the concentrations used for comparison to environmental sample results. The aforementioned methodologies for evaluating blanks were implemented during independent third party analytical data validation prior to the selection of COPCs in the risk assessment.

Essential Nutrients - Despite their inherent toxicity, certain inorganic constituents are essential nutrients. Essential nutrients need not be considered further in the baseline RA if they are present in relatively low concentrations (i.e., slightly elevated above naturally occurring levels), or if the constituent is toxic at doses much higher than those which could be assimilated through exposures at the site (USEPA, 1989b). Elements evaluated as essential nutrients include calcium, magnesium, potassium and sodium. Although iron is considered an essential nutrient, it is evaluated quantitatively in this RA since toxicity criteria are available for this analyte.

Prevalence - The prevalence of a chemical in an environmental medium can be described by the frequency and concentration with which it is detected. A detection frequency greater than, or equal to 5 percent (e.g., 1 positive detection in 20 samples) was considered the minimum criteria for the selection of COPCs in data sets comprised of 20 or more samples. Data sets with fewer than 20 samples were evaluated for any positive detections to determine whether the chemical should be included as a COPC.

6.1.2 Re-inclusion of Chemicals as COPCs

Chemicals can be re-included as COPCs for quantitative evaluation in the baseline RA, despite having been eliminated as such from a comparison to COC values (or other aforementioned criteria). For example, a chemical that was detected with a frequency of less than five percent, at concentrations below the corresponding COC value, may be re-included as a COPC if a chemical is considered a Class A carcinogen (human carcinogen), or if it is reasonable to assume that the chemical could be site-related (especially if it has been detected in other media of concern).

Chemicals also may be selected or re-included as COPCs if detected concentrations exceed the following Federal/Commonwealth standards or criteria.

Maximum Contaminant Levels - MCLs are potentially enforceable standards for public water supplies promulgated under the Safe Drinking Water Act and are designed for the protection of human health. MCLs have been adopted as enforceable standards for public drinking water systems, and apply to drinking water supplies consumed by a minimum of 25 persons. They have been developed for the prevention of human health effects associated with lifetime exposure (70 year lifetime) of an average adult (70 kg) consuming 2 liters of water per day. MCLs also consider the technical and economic feasibility of removing the constituent from a public water supply (USEPA, 1996).

Virginia Drinking Water Standards - Virginia Drinking Water Standards are the maximum contaminant level concentrations of a contaminant in water which is delivered to the users of a public water system. With the exception of nitrate, all inorganic chemical contaminant levels are based on potential adverse health effects resulting from long term exposure to the contaminant in drinking water. The maximum contaminant levels for organics apply to community water supplies, the volatile organics also apply to nontransient, noncommunity water systems.

Virginia Water Quality Standards (WQS) for the Protection of Human Health - The WQSs are Commonwealth-enforceable standards used for identifying the potential for human health risks. WQSs are protective of human health and consider potential carcinogenic and noncarcinogenic health effects in humans from ingestion of both water (2 liters/day) and aquatic organisms (6.5 grams/day), or from ingestion of water alone (2 liters/day). Commonwealth WQSs available

for the protection of human health from potential carcinogenic substances are derived based on an incremental lifetime cancer risk of one additional case of cancer in an exposed population of 100,000 persons (i.e., 1 x 10^{-05}).

Federal Ambient Water Quality Criteria (AWQC) - AWQC are non-enforceable regulatory guidelines and are of primary utility in assessing acute and chronic toxic effects in aquatic organisms for surface water bodies. AWQCs consider acute and chronic effects in both freshwater and saltwater aquatic life, and potential carcinogenic and noncarcinogenic health effects in humans from ingestion of both water (2 liters/day) and aquatic organisms (6.5 grams/day), or from ingestion of organisms alone (6.5 grams/day). The AWQCs for protection of human health for potential carcinogenic substances are based on the USEPA's specified incremental cancer risk range of one additional case of cancer in an exposed population of 10,000,000 to 100,000 persons (i.e., the 1.0 x 10^{-07} to 1.0 x 10^{-05} range). The AWQCs used for comparison in this baseline RA included the human health recalculated values for water and organisms, and organisms only. Published criteria were used in the absence of recalculated values.

6.1.3 Selection of COPCs

Four environmental media (soil, groundwater, surface water, and sediment) were investigated at Sites 1 and 3. The data used in this RA was comprised of data collected for the Round Two RI for Sites 1 and 3. Round Two data was used in the baseline risk assessment since it was considered more complete and representative of current site conditions. Round One data was excluded due to the fact that it was collected in 1992, and surface soil samples were collected from the 0-2 feet depth interval. This is inconsistent with what is used in a baseline RA (i.e., 0-6 inch depth interval).

After the Round Two investigation, a "hot spot" area was identified in the surface soil at Site 3. Very high concentrations of PAHs were detected in this area. Confirmatory surface soil samples and one subsurface soil sample were collected within the "hot spot" area and included in this RA. It should be noted that a removal action is planned for this "hot spot" area in the soils at Site 3. The RA evaluates potential surface soil exposures prior to and after "hot spot" removal as current and future scenarios.

The selection of soil COPCs at each site was stratified to include the surface soil (0- to 6-inches bgs) and the subsurface soil (greater than 6-inches bgs) by depth interval. The selection of groundwater COPCs was stratified by aquifer to include the Columbia aquifer (Site 1) and the Cornwallis Cave/Yorktown-Eastover aquifer (Sites 1 and 3). Each of the stratifications, identified for both the soil and groundwater were evaluated individually. Site 1 and Site 3 surface water and sediment data were combined since both sites lie along the headwaters of the Indian Field Creek. Furthermore, calcium, magnesium, potassium, and sodium were detected in almost every sample, regardless of the medium; however, these constituents were considered to be essential nutrients and were therefore, not retained as COPCs in any medium under investigation at Sites 1 and 3.

Tables 6-2 through 6-9 present the selection of COPCs for each environmental medium based on maximum detected concentration with the USEPA Region III COC values, and other applicable criteria. Constituents retained as COPCs are indicated by the shaded areas in the tables. Information is presented in these tables only for those constituents detected at least once, in the medium of interest. Other statistical information is presented in Appendix 6A.

The following paragraphs present the rationale for selection of COPCs. Sample locations, analytical results, and corresponding figures are presented in other sections of this RI report.

6.1.3.1 Surface Soil

During the Round Two investigation, twenty-one surface soil samples (18 environmental and 3 duplicates) from Site 1 and sixteen surface soil samples (14 environmental and 2 duplicates) from Site 3 were collected from the 0- to 6-inch interval and analyzed for SVOCs, pesticides, PCBs, nitramine compounds, and inorganics (metals). Additionally, five confirmatory surface soil samples were collected at Site 3 around location 3SS10 and analyzed for SVOCs under a supplemental investigation. This small area of Site 3 is referred to as the SVOC Area of Concern (AOC). The COPC selection summaries for surface soil in Site 1 and Site 3 are presented in Tables 6-2 through 6-3B and discussed below. Frequencies of detection (i.e., numbers of detects/total number of samples analyzed) are provided in parentheses.

Site 1

Surface soil samples collected from Site 1 were not analyzed for VOCs. Therefore, no VOCs were retained as surface soil COPCs for Site 1.

Table 6-2 shows that SVOCs, including primarily PAHs and phthalate esters, were detected in the surface soil. Of the 13 positively-detected PAHs, one cPAH, benzo(a)pyrene (6/21) exceeded its corresponding residential COC value and was retained as a surface soil COPC. The three positively-detected phthalate esters did not exceed their respective residential COC values and were therefore, not retained as surface soil COPCs. 2,4-Dinitrotoluene also was detected in the surface soil, but did not exceed its respective residential soil COC value and was therefore, not retained as a surface soil COPC.

Four pesticides were detected in the surface soil, with none exceeding their corresponding residential COC values; therefore, pesticides were not retained as surface soil COPCs at Site 1. One PCB, Aroclor-1260 (1/21), was detected in surface soil samples. Aroclor-1260 did not exceed its residential soil COC value and was therefore, not retained as a COPC.

Twenty-one surface soil samples were analyzed for nitramine compounds. No nitramine compounds were detected in Site 1 surface soil. Therefore, no nitramine compounds were retained as surface soil COPCs.

Inorganics were detected in all surface soil samples collected. The maximum detected concentrations of aluminum, arsenic, beryllium, and iron exceeded corresponding Region III residential COC values. Therefore, the aforementioned constituents were retained as surface soil COPCs for quantitative evaluation in the baseline RA.

Site 3

Surface soil samples collected from Site 3 were not analyzed for VOCs. Therefore, no VOCs were retained as surface soil COPCs.

Table 3-3A shows that PAHs were detected in the Site 3 surface soil. Of the eight positively-detected cPAHs and nPAHs, only benzo(a)pyrene (1/15)exceeded its corresponding residential COC values and was retained as a surface soil COPC.

Three pesticides were detected in the Site 3 surface soil, none of which exceeded corresponding residential COC values. Therefore, pesticides were not retained as surface soil COPCs. One PCB, Aroclor-1260 (2/15), was detected in surface soil samples. Aroclor-1260 did not exceed its residential soil COC value and was therefore, not retained as a COPC.

Inorganics were detected in all surface soil samples collected. The maximum detected concentrations of aluminum, antimony, arsenic, beryllium, iron, and manganese exceeded the corresponding Region III residential COC values. Therefore, the aforementioned constituents were retained as Site 3 surface soil COPCs for quantitative evaluation in the baseline RA.

Site 3 - SVOC AOC

Five surface soil samples were collected from Site 3 under a confirmatory soil investigation. These samples were collected in the vicinity of location 3SS10, a "hot spot" area. In this "hot spot" area, very high concentrations of PAHs were detected in the surface soil. The analytical results from these confirmatory samples were added to the analytical results from sample 3SS10. These confirmatory surface soil samples were analyzed for SVOCs only. These results are presented in Table 6-3B.

Of the 18 positively-detected cPAHs and nPAHs, seven exceeded their corresponding residential soil COC screening values and were retained as surface soil COPCs. They were carbazole (6/6), benzo(a)anthracene (6/6), benzo(b)fluoranthene (6/6), benzo(k)fluoranthene (6/6), benzo(a)pyrene (6/6), indeno(1,2,3-cd)pyrene (6/6), and dibenzo(a,h)anthracene (5/6). Also, dibenzofuran and bis(2-ethylhexyl)phthalate were detected, but at maximum concentrations below respective residential soil COC screening values. Therefore these SVOCs were not retained as surface soil COPCs for the SVOC area of concern.

Five pesticides were detected in sample 3SS10. Dieldrin, endosulfan sulfate, methoxychlor, and endrin ketone were detected at maximum concentrations below their respective residential soil COC screening values. Therefore, these pesticides were not retained as surface soil COPCs.

Inorganics were detected in sample 3SS10. Of the positively detected inorganics, aluminum, arsenic, beryllium, iron, manganese, and vanadium were detected at maximum concentrations that exceeded their corresponding residential soil COC screening values. Therefore, these analytes were retained as surface soil COPCs for the Site 3 SVOC AOC.

6.1.3.2 Subsurface Soil

Up to three subsurface soil samples were collected from each soil boring location within Sites 1 and 3. These samples were collected from the 1- to 3-feet (bgs) interval, a midpoint interval between ground surface and the water table, and an interval just above the water table. Samples collected below 10-feet were used solely for delineating the vertical extent of soil contamination and were not included in the baseline RA. Subsurface soil below 10-feet is not considered a significant source of exposure since exposure pathways are incomplete at such depths.

In total, thirteen shallow subsurface soil samples (10 environmental samples and 3 duplicate samples) from Site 1 and seven shallow subsurface soil samples (5 environmental samples and 2 duplicate samples) from Site 3 were obtained. Each sample was analyzed for VOCs, SVOCs, pesticides, PCBs, nitramine compounds, and inorganics. The COPC selection summaries for subsurface soil in Sites 1 and 3 are presented in Tables 6-4 and 6-5, respectively.

Site 1

Table 6-4 shows that one VOC, acetone (1/13), was detected in the Site 1 shallow subsurface soil samples. However, the maximum concentration of acetone did not exceed the residential soil COC value or ten times the maximum blank concentration and was therefore, not retained as a shallow subsurface soil COPC.

SVOCs, primarily PAHs and phthalate esters, were detected in Site 1 shallow subsurface soil. Of the 10 positively-detected PAHs, one cPAH, benzo(a)pyrene (3/13), exceeded its corresponding residential COC value and was retained as a shallow subsurface soil COPC. The three positively-detected phthalate esters did not exceed their respective residential COC values and were therefore, not retained as shallow subsurface soil COPCs.

Six pesticides were detected in the shallow subsurface soil, none of which exceeded corresponding residential COC values. Therefore, pesticides not were retained as shallow subsurface soil COPCs. One PCB, Aroclor-1260 was also detected in the shallow subsurface soil but did not exceed the residential COC value and was therefore, not retained as a shallow subsurface soil COPC at Site 1.

Inorganics were detected in all shallow subsurface soil samples collected. The maximum detected concentrations of arsenic, beryllium, and iron exceeded their corresponding USEPA Region III COC values. Therefore, the aforementioned constituents were retained as shallow subsurface soil COPCs for quantitative evaluation in the baseline RA.

Site 3

Table 6-5 shows that five VOCs were detected in Site 3 shallow subsurface soil samples: acetone (4/7), methylene chloride (1/7), total 1,2-DCE (2/7), 2-butanone (2/7), and ethylbenzene (2/7). None of the aforementioned VOCs exceeded their corresponding COC screening values and therefore, were not retained as shallow subsurface soil COPCs.

Five SVOCs were detected in shallow subsurface soil samples collected from Site 3. The four PAHs and one phthalate ester did not exceed their corresponding COC screening values. Therefore, these SVOCs were not retained as shallow subsurface soil COPCs.

Two pesticides, 4,4'-DDE (1/7) and 4,4'-DDD (1/7), were detected in shallow subsurface soil at Site 3 at maximum concentrations below their respective residential soil COC screening values. These two pesticides therefore, were not retained as shallow subsurface soil COPCs.

Inorganics were detected in all shallow subsurface soil samples collected. The maximum detected concentrations of aluminum, arsenic, beryllium, chromium, iron, manganese, and vanadium

exceeded their corresponding USEPA Region III residential soil COC values. Therefore, the aforementioned constituents were retained as shallow subsurface soil COPCs for quantitative evaluation in the baseline RA.

Additionally, one confirmatory subsurface soil sample (location 3SB10) was taken from the 1.5 to 2 foot depth interval in the SVOC AOC at Site 3 and analyzed for SVOCs only. For the purposed of this RA, the analytical results were evaluated qualitatively rather than quantitatively, since a soil removal action is planned for this area. The positive detection results from this sample can be found in Section 4.0 of this report, Table 4-22.

Of the seven positively detected nPAHs, none exceeded their respective residential soil COC screening values. Pentachlorophenol and bis(2-ethylhexyl)phthalate were also detected at concentrations below their respective residential COC screening values. Of the six positively detected cPAHs, only benzo(a)pyrene was detected at a concentration that exceeded it residential soil COC screening value. However, it should be noted that a soil removal action is planned for this SVOC AOC at Site 3.

6.1.3.3 Groundwater

Tables 6-6 and 6-7 summarize the COPC selections performed for constituents detected in groundwater samples collected from the Columbia aquifer (located beneath Site 1, only) and the Cornwallis Cave/Yorktown-Eastover aquifer (located beneath both Sites 1 and 3). All samples were analyzed for VOCs, SVOCs, pesticides, PCBs, nitramine compounds, and unfiltered (total) and filtered (dissolved) inorganics. Separate discussions for the selection of COPCs in the two groundwater aquifers are presented below.

Columbia aquifer (Site 1)

Table 6-6 shows that two VOCs were detected in the groundwater samples collected from the Columbia aquifer: 1,2-DCE (1/11) and TCE (2/11). Both of these constituents exceeded their Region III tap water COC values and were retained as groundwater COPCs. TCE also exceeded the Federal MCL and Virginia primary maximum contaminant level (PMCL).

One SVOC, pentachlorophenol (1/11), was detected in the Columbia aquifer groundwater. It was detected at a concentration that exceeded its tap water COC screening value and was therefore, retained as a groundwater COPC.

Eleven groundwater samples collected from the Columbia aquifer were analyzed for pesticides and PCBs. Pesticides and PCBs were not detected in Columbia aquifer groundwater samples. Therefore, no pesticides or PCBs were retained as groundwater COPCs.

One nitramine compound, nitrobenzene (3/11), was detected in the Columbia aquifer at Site 1. All detected concentrations exceeded the tap water COC screening value for nitrobenzene. Therefore, nitrobenzene was retained as a groundwater COPC.

Of the unfiltered (total) inorganics detected in the groundwater arsenic, cadmium, iron, manganese, and zinc were retained because of exceedances of the COC value or one or more of the other criteria. Filtered (dissolved) arsenic, cadmium, iron, manganese, and zinc also exceeded one or more criteria and were retained as groundwater COPCs for quantitative evaluation.

Cornwallis Cave/Yorktown-Eastover Aquifer (Sites 1 and 3)

Table 6-7 shows that seven VOCs were detected in the Cornwallis Cave/Yorktown-Eastover aquifer groundwater samples collected from Sites 1 and 3; they included: vinyl chloride (1/17), acetone (1/17), 1,1-DCE (1/17), 1,2-DCE (4/17), chloroform (1/17), TCE (8/17), and toluene (1/17). The maximum detected concentrations of vinyl chloride, 1,1-DCE, 1,2-DCE, and TCE exceeded one or more corresponding groundwater criteria and were retained as groundwater COPCs. It should also be noted that there were prior detections of TCE at these sites. Acetone and toluene did not exceed either the groundwater criteria or ten times the maximum associated blank concentration. Although chloroform exceeded its COC screening value, it did not exceed five times the maximum associated blank concentration. As a result, acetone, toluene, and chloroform were qualified as laboratory contaminants according to the USEPA guidance presented in RAGS (USEPA, 1989b) and not included as groundwater COPCs.

Four SVOCs, phenol (1/17), phenanthrene (3/17), pyrene (1/17) and di-n-octylphthalate (2/17), were detected in the Cornwallis Cave/Yorktown-Eastover aquifer. None of detected concentrations

exceeded corresponding COC screening values. Consequently, no SVOCs were retained as groundwater COPCs.

Pesticides, PCBs, and nitramine compounds were not detected in the groundwater samples collected from the Cornwallis Cave/Yorktown-Eastover aquifer; therefore, none were retained as groundwater COPCs.

Of the total inorganics detected in the Cornwallis Cave/Yorktown-Eastover aquifer, arsenic, cadmium, chromium, iron, lead, manganese, and vanadium were retained because of exceedances of the COC value or one or more of the other criteria. Dissolved arsenic, cadmium, and manganese also exceeded one or more criteria and were retained as groundwater COPCs for quantitative evaluation.

6.1.3.4 Surface Water

Table 6-8 summarizes the COPC selections performed for constituents detected in surface water for Sites 1 and 3. Four samples (3 environmental and 1 duplicate) were analyzed for VOCs, SVOCs, pesticides, PCBs, nitramine compounds, and total and dissolved inorganics.

No organic compounds (i.e., VOCs, SVOCs, pesticides/PCBs, or nitramine compounds) were detected in the surface water samples. Therefore, no organic compounds were retained as surface water COPCs for Sites 1 and 3.

Inorganics were detected in a majority of the surface water samples collected. All detected concentrations of total cadmium (4/4) and iron (4/4) exceeded the evaluation criteria. Therefore, cadmium was retained as a surface water COPC for quantitative evaluation in the baseline RA. Dissolved cadmium (3/4), and copper (4/4) also exceeded one or more of the evaluation criteria; therefore, they were retained as surface water COPCs.

6.1.3.5 Sediment

Sediment samples collected from Sites 1 and 3 were analyzed for VOCs, SVOCs, pesticides, and PCBs and inorganics. Samples were collected from both the 0- to 4-inch and the 4- to 8-inch

intervals at each sampling location for a total of ten sediment samples (9 environmental and 1 duplicate sample). The COPC selection summaries for sediment are presented in Table 6-9.

Three VOCs including acetone (4/10), carbon disulfide (3/10), and toluene (1/10) were detected in sediment samples. Acetone and toluene did not exceed ten times the maximum detected concentration in associated blanks. Therefore, these constituents were not retained as sediment COPCs. Carbon disulfide was detected and retained as a sediment COPC since it was not detected in blanks. However, it should also be noted that carbon disulfide has been associated with vegetative decay (Verschueren, 1983).

SVOCs, pesticides and PCBs were not detected in sediment samples at Sites 1 and 3; therefore, none were retained as sediment COPCs.

Inorganics were detected in a majority of sediment samples collected. The maximum detected concentrations of arsenic (8/10), cadmium (1/10), and lead (10/10) exceeded one or more screening values. Therefore, the aforementioned constituents were retained as sediment COPCs for quantitative evaluation in the baseline RA.

6.1.4 Summary of COPCs

Table 6-10 presents the summary of COPCs by medium for Sites 1 and 3.

6.2 Exposure Assessment

The exposure assessment addresses each potential current and future exposure pathway in soil, groundwater, surface water, sediment, and air. To determine whether human exposure could occur at Sites 1 and 3 in the absence of remedial action, an exposure assessment which identifies potential exposure pathways and receptors was conducted. The following four elements were considered to ascertain whether a complete exposure pathway was present (USEPA, 1989b):

- A source and potential mechanism of chemical release
- An environmental retention or transport medium
- A point of potential human contact with the contaminated medium

- An exposure route (e.g., ingestion) at the contact point

The exposure scenarios discussed herein represent USEPA's Reasonable Maximum Exposure (RME). Relevant equations for assessing intakes and exposure factors were obtained from RAGS (USEPA, 1989b), Exposure Factors Handbook (USEPA, 1989a), Dermal Exposure Assessment: Principles and Applications, Interim Report (USEPA, 1992a), and Standard Default Exposure Factors, Interim Final (USEPA, 1991a). Due to the overly conservative nature of the residential RME scenarios, residential central tendency (CT) exposure scenarios were also evaluated. Unless otherwise noted, all statistical data associated with the factors used in the dose evaluation equations for assessing exposure were obtained from the Exposure Factors Handbook and the accompanying guidance manuals.

As a result, the residential exposure scenarios presented in this baseline RA include both RME and CT assumptions for the input parameters in the dose evaluation equations. Thus, for each chemical, under each exposure scenario associated with unacceptable risk, a range of chemical intakes is calculated that is defined by the CT and RME assumptions. For parameters having no established USEPA default CT assumptions, the same value used for the RME scenario was applied.

WPNSTA Yorktown will continue to function as one of the key Naval ordnance installations on the East Coast for the foreseeable future. Station housing for enlisted personnel is limited to areas around the golf course; Mason Row (senior officers quarters), which overlooks the York River; and cottage-style homes scattered throughout the Station. There is currently no Station housing of enlisted personnel at Sites 1 and 3.

The Station has been divided by the Navy into three basic land use areas: (1) explosive/ordnance storage, (2) ordnance production/maintenance, and (3) non-explosive and support functions (DoN, 1991). Categorized from an "explosives" standpoint, two general land use patterns emerge: real estate encumbered by the Explosive Safety Quantity Distance (ESQD) arc and that which is not encumbered. Sites 1 and 3 are located inside an area encumbered by the ESQD arc and therefore, cannot be developed for Station housing of enlisted personnel.

There are no drinking water wells at WPNSTA Yorktown. Drinking water is supplied by the City of Newport News. There are, however, five supply wells at WPNSTA Yorktown, located at

Buildings 120, 352, 304, 28 (all for fire-fighting purposes), and Gate 13. Due to the poor water quality, the wells located at Buildings 120, 352, and 304, have been decommissioned and capped; the well at Building 28 was abandoned and filled with cement. The remaining well at Gate 13 is a newer well that supplies water to the toilet facilities which are a part of the weigh station. Though approved by the Virginia Department of Health for potable use, drinking water at Gate 13 is supplied in the form of bottled water. Gate 13 is located in the western portion of WPNSTA Yorktown, approximately 3.6 miles southwest of Sites 1 and 3.

Current potential human receptors to COPCs detected in environmental media at Sites 1 and 3 are limited to on-Station adult and adolescent trespassers. Although future residential development of Sites 1 and 3 is highly unlikely, future residential exposure for potential adult and child receptors was considered in keeping with USEPA guidance. As a conservative approach (since the shallow aquifer system within WPNSTA is not used as a potable water source), child and adult residents were considered to be potentially exposed to organic and dissolved inorganic COPCs in the Columbia and Cornwallis Cave/Yorktown-Eastover aquifers at Site 1 and the Cornwallis Cave/Yorktown-Eastover aquifer at Site 3. Total inorganic results were not evaluated since dissolved inorganic results are considered to be more representative of drinking water conditions at the tap. In addition, future construction workers that may perform excavation and housing construction activities, were evaluated as potential receptors.

6.2.1 Potential Human Receptors

The potential human receptors and exposure routes evaluated at Sites 1 and 3 were selected considering current and future potential land use in accordance with the Master Plan for WPNSTA Yorktown (DoN, 1991). The following paragraphs present the rationale for the selection of potential exposure pathways for human receptors at Sites 1 and 3.

Based on information available regarding the physical features, site setting, site historical activities, and current and expected land uses, seven potential human receptors have been selected for evaluation. These include:

- Current On-Station Adolescent Trespassers (7-15 years)
- Current On-Station Adult Trespassers

- Future Resident Children (1-6 years)
- Future Resident Adults
- Future Adult Construction Workers

Potential on-Station trespassers include Station personnel and younger family members that may access the site for recreational purposes. Potential exposure to COPCs and media of concern for the current on-Station adult and adolescent trespassers include accidental ingestion and dermal contact with the surface soil, surface water, and sediment. Fugitive dust generation from surface soil is not considered to be a significant potential release mechanism at either site since they are covered to a great extent by vegetation. None of the trespassers were evaluated for recreational fishing and consumption of fish, since no fishing occurs at or around Sites 1 and 3.

Despite the unlikely nature of residential development by the military or general public, future residential exposure by children and adults will be evaluated. The future adult and child residential receptors could potentially be exposed to COPCs in surface soil, groundwater, surface water, and sediment, by ingestion, dermal contact and inhalation of volatiles (adults, only) present in the shower water (groundwater). As with the on-Station trespasser receptor, fugitive dust generation from surface soil is not considered to be a significant potential release mechanism.

Potential exposure to COPCs at Sites 1 and 3 could occur in the future if utilities or buildings in the area are constructed. The future construction worker will therefore be evaluated for accidental ingestion, dermal contact, and inhalation of fugitive dust in shallow subsurface soil during excavation activities. Surface soil exposure is not evaluated for this receptor because most of the exposure would be to subsurface soil in an excavation scenario. This is discussed further in Section 6.5.3 as a possible uncertainty.

In summary, the following potential human exposure receptors and exposure pathways are being retained for quantitative evaluation in this baseline RA.

- Current On-Station Adult and Adolescent (7-15 years old) Trespassers:
  Accidental ingestion of surface soil
  Dermal contact with surface soil
  Accidental ingestion of surface water

Dermal contact with surface water
Accidental ingestion of sediment
Dermal contact with sediment

- Future On-Site Adult and Child (1-6 years old) Residents:
  Accidental ingestion of surface soil
  Dermal contact with surface soil
  Ingestion of groundwater used as drinking water
  Dermal contact with groundwater while bathing
  Inhalation of volatiles in groundwater while showering (adults only)
  Accidental ingestion of surface water
  Dermal contact with surface water
  Accidental ingestion of sediment
  Dermal contact with sediment

- Future On-Site Adult Construction Workers:
  Accidental ingestion of shallow subsurface soil
  Dermal contact with shallow subsurface soil
  Inhalation of fugitive dust in shallow subsurface soil

6.2.2 Conceptual Site Model

Development of a conceptual site model of potential exposure is critical in evaluating all potential exposures for the aforementioned human receptors. The conceptual site model describes the area of concern in terms of potential sources of contamination, affected media, and all potential routes of migration of the contaminants present. Conceptual site models for Sites 1 and 3 are presented in Figures 6-1 and 6-2, respectively.

6.2.3 Quantification of Exposure

The chemical concentrations used in the estimation of chronic daily intakes (CDIs) and dermally absorbed doses (DADs) for each medium are considered to be representative of the types of potential exposure encountered by each receptor. Exposure can occur discretely or at a number of sampling

locations depending on the type of scenario considered for a given receptor. Furthermore, certain environmental media such as groundwater and surface water are migratory and chemical concentrations detected in these media change frequently over time. Soil and sediment are, by nature, less transitory. The manner in which environmental data are represented also depends on the number of samples and sampling locations available for a given area and a given medium.

To quantify exposure, analytical data must be evaluated to determine its distributional nature. In general, two types of distributions are applied to environmental data; these are the normal and log-normal distributions. For example, most large data sets from soil sampling are log-normally distributed rather than normally distributed. The geometric mean is the best estimator of central tendency for a log-normal data set (USEPA, 1992d). However, most Agency health criteria are based on the long-term average exposure which is expressed as the sum of all daily intakes divided by the total number of days in the averaging period. The geometric mean of a set of sampling results may not adequately represent random exposure and the cumulative intake that would result from long-term contact with site contaminants.

Potential exposure to soil, surface water, and sediment at Sites 1 and 3, regardless of location, is considered as having an equal probability of occurrence as an individual moves randomly across the site. Therefore, for these media, the exposure point concentration for a constituent in the intake equation can be reasonably estimated as the arithmetic average concentration of site sampling data. USEPA supplemental risk assessment guidance (USEPA, 1992d) states that the average concentration is an appropriate estimator of the exposure concentration for two reasons: 1) carcinogenic and chronic noncarcinogenic toxicity criteria are based on lifetime average exposures; and 2) the average concentration is most representative of the concentration that would be contacted over time. However, uncertainty is inherent in the estimation of the true average constituent concentration at the site.

In order to account for this uncertainty and to be health protective, USEPA risk assessment guidance (USEPA, 1989b) requires that an upper bound estimate of the arithmetic mean concentration, be used to calculate CDI. This estimate, which should be in the high end of the concentration frequency distribution, is called the RME concentration. The RME concentration is defined as the highest concentration that could reasonably be expected to be contacted via a given pathway over a long-term exposure period.

A conservative estimate of the arithmetic average concentration that best represents the RME is the 95% upper confidence limit of the arithmetic mean concentration (95% UCL). In order to estimate the 95% UCL for soil, surface water, and sediment data sets, a normal distribution was assumed to represent the occurrence of all COPC-detected concentrations for sample data sets greater than or equal to five. Furthermore, if the 95% UCL of the arithmetic mean exceeds the maximum detected concentration in a given data set, the maximum detected concentration will be used to represent the concentration term for that COPC.

The 95% UCL was calculated using the following equation (USEPA, 1992d):

$$95\%\ UCL = \bar{x} + t(s/\sqrt{n})$$

Where:

$\bar{x}$ = mean

s = standard deviation

t = Student t statistic (Gilbert, 1987)

n = number of samples

In addition to the RME risk descriptor, which is represented by the maximum and/or 95% UCL concentration for the selected COPC, the CT risk descriptor was also used for data sets when the RME concentration term showed a potential risk to human health, specifically, to future on-site residents. The CT concentration term was utilized by calculating the arithmetic mean of the data concentrations (CT concentrations); detected concentrations as well as half-detection limit values were utilized in the calculation of the mean. The CT concentrations were then utilized to calculate chemical intakes for the CT-case scenarios.

Volatile organic contamination (e.g., TCE) was encountered in the groundwater from the Columbia aquifer (Site 1) as well as from the Cornwallis Cave/Yorktown-Eastover aquifer (Sites 1 and 3). Therefore, in addition to using the 95% UCL to represent the average groundwater exposure concentration, the maximum detected concentrations from three groundwater wells were also selected: one from the Columbia aquifer (1GW20 [Site 1]) and two from the Cornwallis Cave/Yorktown-Eastover aquifer (1GW12B [Site 1] and 3GW19 [Site 3]). These well locations

were selected because they represent the highest concentrations of TCE that are closest to Indian Field Creek.

Frequency of detection as well as maximum detected values are presented in Appendix 4C. 95% UCL values and mean values, derived for COPCs in all media at Sites 1 and 3 are presented in Appendix 6A. The equations for estimating intakes due to direct exposures to site-related chemicals for the various identified pathways are presented in Appendix 6B. Site-specific shower model calculations (Foster and Chrostowski, 1987) are presented in Appendix 6C for each potential pathway and receptor.

For results reported as "nondetect" (i.e., results flagged with the following validation qualifiers: U, UJ, UL, and UK), a value of one half of the sample-specific detection limit was used to calculate the 95% UCL. A value of half the detection limit was assigned to nondetects when estimating the 95% UCL and the arithmetic mean because the actual value could be between zero and a value just below the detection limit. 95% UCLs were calculated only for the constituents detected in at least one sample collected from the environmental medium of interest. Estimated concentrations also were used to calculate the 95% UCL, such as "J"-qualified (estimated), "L"-qualified (estimated, biased low) and "K"-qualified (estimated, biased high) data. Reported concentrations qualified with an "R" (rejected) were not used in the statistical evaluation.

According to the Region III Modifications to the National Functional Guidelines (NFGs), reported organic and inorganic concentrations that were qualified with a "B" were evaluated against the available field and laboratory blanks. This qualifies the organic/inorganic as a nondetect due to laboratory contamination. For constituents considered by RAGS to be common laboratory blanks, chemicals were deemed positive detects only if their concentration exceeded 10 times the maximum blank concentration. For constituents not considered to be common laboratory contaminants, chemicals were considered as positive detects only if their concentration exceeded 5 times the maximum blank concentration.

6.2.4 Exposure Factors Used To Derive Chronic Daily Intakes

Tables 6-11 through 6-13 present the exposure factors used in the estimation of potential CDIs/DADs for COPCs retained for each receptor identified below. USEPA promulgated exposure factors are used in conjunction with USEPA standard default exposure factors for both the CT and RME exposure scenarios; however, the CT exposure scenario was utilized only for future residential receptors. Furthermore, when USEPA exposure factors are not available, best professional judgment and site-specific information are used to derive a conservative and defensible value. The following paragraphs present the rationale for the RME assumptions for each receptor group evaluated in the baseline RA. The CT assumptions, though not discussed below, are presented in the tables in parentheses.

6.2.4.1 Current Adult and Adolescent On-Station Trespassers

Though unlikely, this scenario assumes that Station personnel, including adolescent family members, would trespass onto the site for recreational purposes. On-Station trespassers were evaluated for potential exposure to surface soil, surface water, and sediment via accidental ingestion and dermal contact while passing through or recreating at the site. Table 6-11 presents the input values used in this baseline RA.

Surface Soil

For potential exposure to surface soil, a 70 kg adult and a 37 kg adolescent (USEPA, 1989b) were assumed to be located at the Station for a term of 4 years (a standard tour of duty assignment for military personnel in any one location), which was assumed to be the exposure duration for these receptors. The skin surface area (SA) available for dermal contact with surface soil was estimated to be 5,300 cm^2 for the adult and 3,480 cm^2 for the adolescent (USEPA, 1992a), representing the skin surface area available for contact assuming an adult/adolescent wears a short-sleeved shirt, short pants, and shoes. Both surface areas represent approximately 25-30% of the median total body surface area. The ingestion rate was assumed to be 100 mg/day (USEPA, 1989b) for the adolescent and the adult, with a 50% fraction of the soil ingested originating from the site. USEPA Region III default dermal absorption values of 0.05% for VOCs, 10% for SVOCs, nitramines and pesticides, 6% for PCBs 1% for inorganics and 3.2% for arsenic were applied in evaluating dermal exposures

to soil (USEPA, 1995a). The exposure potential was expected to occur up to 143 days/year (assuming 3 days/week for the spring and fall months and 5 days/week for the summer months). The averaging time of 1,460 days was assumed for evaluating noncarcinogenic exposure to On-Station adult and adolescent trespassers. An averaging time of 25,550 days was used for evaluating exposures to carcinogens (USEPA, 1989b).

Surface Water

To estimate exposure to surface water assuming a wading scenario, equations and chemical-specific permeability constants (Kp) presented by USEPA (USEPA, 1992a) were used to estimate the absorption of COPCs by skin exposed to surface water. The ingestion rate was 0.05 L/day (USEPA, 1989b) for 2.6 hours per day (USEPA, 1989b). The exposure frequency, exposure duration, body weights, surface area, and the averaging times were the same as those used for the surface soil scenario.

Sediment

To estimate sediment exposure the ingestion rate was assumed to be 100 mg/day for both the adult and adolescent, with a fraction ingested of 50% and a soil to skin adherence factor of 1 mg/cm^2 for the clay mineral kaolin (USEPA, 1992b). The USEPA Region III default absorption values used for evaluating dermal soil exposures were also used for evaluating dermal sediment exposures. The surface area, exposure duration, exposure frequency, averaging time and body weight were the same as those presented for the surface water scenario.

6.2.4.2 Future Child and Adult Residents

Table 6-12 presents the exposure factors used in the estimation of potential CDIs/DADs for the future child and adult residents. Values enclosed by parentheses represent the CT exposure factors. The CT exposure factors were selected from two main sources, the USEPA's Draft Superfund's Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure (USEPA, 1993b) and the USEPA's Interim Dermal Exposure Assessment: Principles and Applications (USEPA, 1992a). The values discussed in the following paragraphs represent the RME

exposure factors selected for this baseline RA; the CT exposure factors are not discussed the following paragraphs, but are identified in Table 6-12.

In the current Master Plan for WPNSTA Yorktown, future residential development of Site 1 or 3 is not projected (DoN, 1991). However, to maintain a conservative approach in accordance with USEPA guidance, the potential exposure pathways associated with future potential residential development were estimated. Future adult and young child (ages 1-6 years) residents were evaluated for potential exposures via ingestion and dermal contact with COPCs in surface soil and groundwater (when used as a potential potable water source). Future adult and child residents also were evaluated for potential exposures from accidental ingestion and dermal contact with surface soil, surface water, and sediment.

Surface Soil

The ingestion rate was assumed to be 200 mg/day for a 15 kg child and 100 mg/day for a 70 kg adult (USEPA, 1989b), with an exposure frequency of 350 days per year (USEPA, 1991a). The fraction ingested was assumed to be 100%. The adult skin SA available for dermal contact with surface soil was estimated to be 5,300 cm^2, representing 25% of the total body surface area at the 95th percentile value (USEPA, 1989a/1992a). A skin SA value of 2,006 cm^2, representing 25% of the total body surface area at the 95th percentile value for a young child (1-6 years) (USEPA, 1989a/1992a). USEPA Region III default dermal absorption values of 0.05% for VOCs, 10% for SVOCs, nitramines and pesticides, 6% for PCBs 1% for inorganics and 3.2% for arsenic were applied in evaluating dermal exposures to soil (USEPA, 1995a). The soil to skin adherence factor of 1 mg/cm^2 for the clay mineral kaolin (USEPA, 1992b) was used to evaluate dermal exposures to soil. The exposure duration was considered to be 24 years for the adult and 6 years for the child. The averaging times were 2,190 days (child) and 8,760 days (adult) for the noncarcinogens and 25,550 days (adult and child) for the carcinogens.

Groundwater

The adult skin SA available for dermal contact with groundwater during bathing was estimated to be 20,000 cm^2, representing total body exposure (USEPA, 1992a). The exposure frequency was assumed to be 350 days/year at 0.2 hours (12 minutes) a day (USEPA, 1989a). Equations and

chemical-specific Kp presented by USEPA (USEPA, 1992a) were used to estimate the absorption of COPCs by skin exposed to groundwater. The exposure duration assumed for the adult was 24 years, with an ingestion rate of 2 L/day (USEPA, 1991a). The respiration rate for the inhalation of volatile organic compounds while showering was assumed to be 0.83 m^3/hour for the adult (USEPA, 1991a). The averaging time and body weight were the same as those presented for the surface soil medium.

A skin SA value of 8,023 cm^2 was used to represent the 95th percentile whole body surface area of a young child (USEPA, 1992a). The exposure frequency, exposure time, and respiration rate are the same as the adult's, however the exposure duration was assumed to be 6 years with an ingestion rate of 1 L/day (USEPA, 1991a). Equations and chemical-specific Kp presented by USEPA (USEPA, 1992a) were used to estimate the absorption of COPCs by skin exposed to groundwater. The averaging times were 2,190 days for the noncarcinogens and 25,550 days for the carcinogens.

Surface Water

The adult skin SA available for dermal contact with surface water was estimated to be 5,300 cm^2, representing 25% of the total body surface area at the 95th percentile value (USEPA, 1989a/1992a). The exposure frequency was assumed to be 40 days/year (assuming 4.3 weekends/month at one day/weekend for 9 months) at 2.6 hours a day (USEPA, 1989b), for 24 years (USEPA, 1991a). Equations and chemical-specific Kp values were used to estimate the absorption of COPCs by skin exposed to surface water. An ingestion rate of 0.05 L/day was also used. The averaging times were 8,760 days for the noncarcinogens and 25,550 days for the carcinogens.

Assuming a wading scenario, a skin SA value of 2,006 cm^2 was used to represent 25% of the total body surface area at the 95th percentile value for a young child (1-6 years) (USEPA, 1989a/1992a). The exposure frequency, ingestion rate, and exposure time are the same as the adult's, however the exposure duration was assumed to be 6 years. As with the adult, equations and chemical-specific Kp were used to estimate the absorption of COPCs by skin exposed to surface water. The averaging times were 2,190 days for the noncarcinogens and 25,550 days for the carcinogens.

Sediment

The ingestion rate was assumed to be 200 mg/day for the child and 100 mg/day for the adult for 40 days per year. The fraction ingested was assumed to be 50%. The soil to skin adherence factor of 1 mg/cm^2 for the clay mineral kaolin (USEPA, 1992b) and the USEPA default dermal absorption values used for soil were also used to estimate sediment exposures. The exposure duration, averaging time and body weight were the same as those presented for the surface water medium.

6.2.4.3 Future Adult Construction Workers

Table 6-13 presents the exposure factors used in the estimation of potential CDIs/DADs for the future adult construction workers. Potential exposures to subsurface soil COPCs may occur to construction workers while performing soil excavation and construction activities. Exposure pathways evaluated include accidental ingestion, dermal contact and inhalation of fugitive dust. Exposure was assumed to occur for 8 hours per day, 250 days per year (USEPA, 1991a), for a construction period of 1 year. A USEPA default value for the soil ingestion rate (480 mg/day), a fraction ingested rate of 100%, and a respiration rate of 20 m^3/day or 0.83 m^3/hour (USEPA, 1991a) were also assumed for a 70 kg construction worker. A skin surface area of 4,300 cm^2 (USEPA, 1992a) was evaluated for dermal contact with subsurface soil. The soil to skin adherence factor of 1 mg/cm^2 for clay mineral kaolin (USEPA, 1992b) and USEPA default dermal absorption values of 0.05% for VOCs, 10% for SVOCs, nitramines and pesticides, 6% for PCBs 1% for inorganics and 3.2% for arsenic were applied in evaluating dermal exposures to subsurface soil (USEPA, 1995a).

6.3 Toxicity Assessment

Section 6.3 presented potential exposure pathways and receptors for this baseline RA. This section will review the available toxicological information for COPCs retained for quantitative evaluation.

An important component of the RA process is the relationship between the dose of a compound (amount to which an individual or population is potentially exposed) and the potential for adverse health effects resulting from exposure to that dose. Dose-response relationships provide a means by which potential public health impacts may be evaluated. Standard reference doses (RfDs) and/or carcinogenic slope factors (CSFs) have been developed for many of the COPCs. This section provides a brief description of these parameters.

6.3.1 Reference Doses

The RfDs and Reference Concentrations (RfCs for inhalation) are developed for chronic and/or subchronic human exposure to chemicals and are based solely on the noncarcinogenic effects of chemical substances. These values are defined as an estimate of a daily exposure level for the human population, including sensitive subpopulations, that is likely to be without an appreciable risk of adverse effects during a lifetime. The RfD is expressed as dose (mg) per unit body weight (kg) per unit time (day). The RfC is expressed as dose (mg) per cubic meter of air (m^3).

6.3.2 Carcinogenic Slope Factors

CSFs are used to estimate an upper bound lifetime probability of an individual developing cancer as a result of exposure to a particular level of a potential carcinogen (USEPA, 1989b). This factor is reported in units of $(mg/kg/day)^{-1}$ and is derived through an assumed low-dosage linear multistage model and an extrapolation from high to low dose-responses determined from animal studies. The value used in reporting the slope factor is the 95% UCL. CSFs can also be derived from USEPA promulgated unit risk values for air and/or water. CSFs derived from unit risks cannot, however, be applied to environmental media other than the medium considered in the unit risk estimate.

Slope factors are also accompanied by weight-of-evidence classifications which designate the strength of the evidence that the COPC is a potential human carcinogen.

Quantitative indices of toxicity and USEPA weight-of-evidence classifications are presented in Table 6-14 for the identified COPCs. The hierarchy (USEPA, 1989b) for choosing these values was:

- Integrated Risk Information System (IRIS) (USEPA, 1996a)
- Health Effects Assessment Summary Table (HEAST) (USEPA, 1995b)
- National Center for Environmental Assessment (NCEA) (USEPA, 1996b)

The IRIS data base is updated monthly and contains both verified RfDs, RfCs and CSFs. The USEPA has formed an RfD work group to review existing data used to derive RfDs and RfCs. Once this task has been completed the verified RfD appears in IRIS. Like the RfD Work Group, the USEPA has also formed the Carcinogen Risk Assessment Verification Endeavor (CRAVE) Work

group to review and validate toxicity values used in developing CSFs. Once the slope factors have been verified via extensive peer review, they also appear in the IRIS data base.

HEAST, on the other hand, provides both interim (unverified) and verified RfDs, RfCs and CSFs. This document is published quarterly and incorporates any applicable changes to its data base.

6.3.3 Dermal Absorption Efficiency

Many of the RfDs and CSFs are derived from oral toxicological studies based on administered dose, and do not account for the amount of a substance that can penetrate exchange boundaries after contact (e.g., absorbed dose). As a result, there is very little information available regarding dermal toxicity criteria. Therefore, in order to account for a difference in toxicity between an administered dose and an absorbed dose, the RfDs and CSFs (that were based on an administered dose) were adjusted, as described by the USEPA (USEPA, 1989b), using experimentally-derived oral absorption efficiencies. The adjustment for the oral RfD that would correspond to a dermally absorbed dose is represented by multiplying the RfD by an oral absorption efficiency. The adjustment for the oral CSF that would correspond to the dermally absorbed dose is represented by dividing the CSF by an oral absorption efficiency. The oral absorption efficiencies were obtained from sources such as the NCEA, IRIS, Agency for Toxic Substance and Disease Registry (ATSDR) toxicological profiles, toxicology publications, toxicology references, and USEPA Regional Offices. In some instances, published information was not available to determine the absorption efficiency, or published information indicated that the absorption efficiency was low for both dermal and oral routes of exposure (i.e., beryllium). On these occasions, adjustments to the toxicity value were not conducted (e.g., an absorption efficiency of 100% was assumed). The absorption efficiencies used in this baseline RA for Sites 1 and 3 are presented in Table 6-14.

6.4 Risk Characterization

The risk characterization combines the selected COPCs, the exposure assessment, and the toxicity assessment to produce a quantitative estimate of current potential human health risks associated with Sites 1 and 3. Estimated ICRs and HIs for the identified potential adult construction worker who could be exposed to COPCs via dermal contact, accidental ingestion, and inhalation of fugitive dust in surface and subsurface soil, current adult and child on-Station trespassers who could be exposed

to COPCs via dermal contact and accidental ingestion of surface soil, surface water, and sediment, and the future adult and child residents who could be exposed to COPCs via dermal contact and ingestion of surface soil, surface water, sediment, and groundwater and the inhalation of volatile groundwater COPCs while showering, are discussed in this section. The ICRs and HIs were calculated for each of the soil, shallow groundwater, surface water, and sediment COPCs using the 95% UCL of the arithmetic mean as the exposure point concentration, or the maximum concentration if the 95% UCL exceeded the maximum. ICRs and HIs were also calculated for three groundwater wells that were chosen to represent the highest concentrations of TCE closest to a surface water body (e.g., Indian Field Creek), using the maximum detected value as the exposure point concentration.

6.4.1 Carcinogenic Compounds

Quantitative risk calculations for potentially carcinogenic compounds estimate inferentially (versus probabilistically) the potential ICR for an individual in a specified population. This unit of risk refers to a potential cancer risk that is above the background cancer risk in unexposed individuals. For example, an ICR of 1×10^{-06} indicates that an exposed individual has an increased probability of one in one million of developing cancer subsequent to exposure, over the course of their lifetime.

The potential lifetime ICR for an individual was estimated from the following relationship:

$$ICR = \sum_{i=1}^{n} (CDI_i \text{ or } DAD_i) \times CSF_i$$

where the CSF_i is expressed as $(mg/kg/day)^{-1}$ for compound i, and the chronic daily intake (CDI_i) and dermally absorbed dose (DAD_i) is expressed as mg/kg/day for compound i. Since the units of CSF are (mg chemical/kg body weight-day)$^{-1}$ and the units of intake or dose are [mg chemical/kg body weight-day], the ICR value is dimensionless. The aforementioned equation was derived assuming that cancer is a nonthreshold process and that the potential excess risk level is proportional to the cumulative intake over a lifetime.

For quantitative estimation of risk, it is assumed that cancer risks from various exposure routes are additive. Estimated ICR values will be compared to 1×10^{-06} to 1×10^{-04} which represents the target

risk range of ICR values considered by the USEPA to represent an acceptable (i.e., de minimis) risk (USEPA, 1990).

6.4.2 Noncarcinogenic Compounds

Noncarcinogenic compounds assume that a threshold toxicological effect exists. Therefore, the potential for noncarcinogenic effects are calculated by comparing (i.e., dividing) CDI_i and DAD_i levels with RfDs for each COPC.

Noncarcinogenic effects are estimated by calculating the HQ for individual chemicals and the hazard index (HI) for overall chemicals and pathways by the following equation:

$$HI = \sum_{i=1}^{n} HQ_i$$

where: $HQ_i = (CDI_i \text{ or } DAD_i)/RfD_i \text{ or } RfC_i$

An HQ is the ratio of the daily intake or absorbed dose to the reference dose (or reference concentration for inhalation exposure). CDI_i is the chronic daily intake (mg/kg/day) of contaminant i; DAD_i is the dermally absorbed dose (mg/kg/day) of contaminant i, and RfD_i is the reference dose (mg/kg/day) of the contaminant i over a prolonged period of exposure. RfC_i is the reference concentration used when determining exposure due to inhalation. Since the units of RfD are mg/kg-day and the units of CDI/DAD are mg/kg-day, the HQ and HI are dimensionless. To account for the additivity of noncarcinogenic risk following exposure to numerous chemicals, the HI, which is the sum of all the HQs, will be calculated. A ratio of 1.0 is used for examination of the HQ and HI. Ratios less than 1.0 indicate that adverse noncarcinogenic health effects are unlikely. Ratios greater than 1.0 indicate the potential for adverse noncarcinogenic health effects to occur at that exposure level and caution should be exercised. However, this does not mean that adverse effects will definitely be observed since the RfD incorporates safety and modifying factors to ensure that it is well below that dose for which adverse effects have been observed. This procedure assumes that the risks from exposure to multiple chemicals are additive, an assumption that is probably valid for compounds that have the same target organ or cause the same toxic effect.

6.4.3 Potential Human Health Effects

Total risks were estimated by site for all current trespasser and future residential receptors using both the RME and the CT. Risks due to surface soil and subsurface soil were derived and presented on a site specific basis. Risks associated with surface water and sediment were estimated over both Sites 1 and 3. Groundwater risks were estimated by aquifer, as well as for three individual well locations (this will be discussed in the following subsections). Future construction workers were evaluated for subsurface soil exposures for each site.

The most significant carcinogenic and noncarcinogenic risks estimated were for the future resident adult and young child receptors for both sites. The groundwater pathways contributed most predominantly to these elevated risk levels. Tables 6-15 and 6-16 present the total site risks for potential current and future human exposures, respectively, to COPCs identified in environmental media at Sites 1 and 3. Tables 6-17 through 6-20 present a break down of the total site risks by pathways and show the emphasis the different media have on the total ICR and HI values. Exceedences of USEPA acceptable risk criteria are represented by the shaded regions of the tables. Risk calculations and tables presenting the ICR and HI values, by pathway and medium, for current adult and adolescent on-Station trespassers, future on-site adult and child residents, and future adult construction workers at Sites 1 and 3 are presented in Appendix 6D.

Because of site demographics and the location of Site 1 and Site 3 within the ESQD arc, current potential human receptors at the two sites are limited to adult and adolescent (ages 7-15 years) on-station trespassers. Table 6-15 shows that the total site ICR values derived for each of the current potential human receptors fell within the USEPA's generally acceptable target risk range of 1×10^{-06} to 1×10^{-04} in Site 1. The total site HI values estimated for the trespassers were below unity (refer to Table 6-15) for both sites. Table 6-15 also shows that the total site ICR values for the adult and adolescent trespassers exceeded the acceptable target risk range. This unacceptable ICR resulted from the surface soil in the SVOC AOC. The risks are broken down by media and pathway in Table 6-17.

Table 6-16 shows that conservative RME future adult and young child residential use scenarios evaluated for Sites 1 and 3 resulted in unacceptable ICR values (i.e., greater than 1×10^{-04}) and HI values (i.e., greater than 1.0). Risks are presented in Table 6-18 and Table 6-19 for adults and

children as individual receptors. The risks for all four media (surface soil, groundwater, surface water, and sediment) were summed in each area according to location of assumed potable sources of groundwater for domestic uses. Groundwater exposure concentrations were assumed using 95%UCL (or maximum) concentrations produced by averaging separately over wells in the Columbia aquifer (under Site 1) and the Cornwallis Cave (under Sites 1 and 3), as well as measured concentrations observed for individual monitoring well locations 3GW19 (Site 3, Cornwallis Cave/Yorktown-Eastover aquifer), 1GW12B (Site 1, Cornwallis Cave/Yorktown-Eastover aquifer), and 1GW20 (Site 1, Columbia aquifer). These groundwater wells represent those with the highest concentration of TCE and closest to Indian Field Creek. Therefore, for Site 1, four sets of total risks and for Site 3, two sets of total risks were estimated based on groundwater exposure locations. However, it should be noted that the assumption of residential land use is extremely conservative since the property use at WPNSTA Yorktown is not anticipated to change in the foreseeable future because of its importance as a weapons storage facility. The future residential use scenario is being evaluated as part of the human health risk assessment as required by USEPA Region III (Baker, 1994).

In addition, due to the conservative nature of the RME evaluation of future residential land use, residential risks were also evaluated under a set of exposure concentrations and assumptions that approximates CT. CT risks are presented in all residential risk characterization tables in parentheses. Table 6-16 presents total residential lifetime risks resulting from sums of adult and child risks for each area and potable source scenario. As can be seen from this table, RME carcinogenic and noncarcinogenic residential lifetime risks exceed acceptable criteria for all scenarios. Under CT scenarios, Table 6-16 shows that all total noncarcinogenic risks for the four potable source scenarios for Site 1 exceed USEPA acceptable criteria while all but one of the carcinogenic risks are within USEPA's acceptable risk range. In addition, Table 6-16 shows that for Site 3, all total carcinogenic and noncarcinogenic risks for both potable source scenarios exceed acceptable criteria.

Table 6-16 also shows that future adult construction workers at Sites 1 and 3 exhibited total site ICR values within the generally acceptable target risk range. In addition, the total site HI for future construction workers at Site 1 was below the acceptable risk value of 1.0. However, the total site HI for future construction workers at Site 3 exceeded unity. These unacceptable risk from Site 3 subsurface soil is broken down by media and presented in Table 6-20.

The sections that follow will focus on the aforementioned scenarios and those COPCs and environmental media which may result in potential adverse human health risks. These risks are presented in Tables 6-17 through 6-20. Tables for scenarios resulting in total carcinogenic and noncarcinogenic risks that were within USEPA acceptable criteria are presented in Appendix 6E and are not discussed below.

6.4.3.1 Current On-Station Adult and Adolescent Trespassers at Site 1

The following subsections describe the resultant risk values derived for exposures of potential current on-station adult and adolescent trespassers to COPCs identified in surface soil at Site 1, Sites 1 and 3 surface water (estimated for organic and total inorganic COPCs), and Sites 1 and 3 sediment. Since no unacceptable risks resulted for on-Station trespassers at Site 1, only RME scenarios were evaluated for trespassers. These scenarios are not discussed, but are presented in Appendix 6E.

6.4.3.2 Current On-Station Adult and Adolescent Trespassers at Site 3

Table 6-17 presents the carcinogenic and noncarcinogenic risk values derived for exposures of potential current on-Station adult and adolescent trespassers to COPCs identified in surface soil at Site 3, Sites 1 and 3 surface water (estimated for organic and total inorganic COPCs), and Sites 1 and 3 sediment. The total ICR values for adult (ICR=1.7 x 10^{-04}) and adolescent (ICR=2.2 x 10^{-04}) trespassers under the RME exposure scenario, summed over all media, exceed USEPA acceptable criteria. These unacceptable ICR values were due to potential dermal contact with the SVOC AOC surface soil. All total ICRs were within USEPA's target risk range when CT exposure scenarios were evaluated. In addition, the ICR values fell within the target risk range when the SVOC AOC was removed from the risk calculations. This is shown in Table 6-17. It should be noted that a removal action is planned for the surface soil at the Site 3 SVOC AOC.

All but one total HI under the RME exposure scenario, summed over all media, fell below the acceptable risk value of one. The total HI for current adolescent trespassers was 1.0. This unacceptable HI included the SVOC AOC. The total HI for current adolescent trespassers fell below one (HI=0.4) when the SVOC AOC was removed from the risk calculations. This is shown in

Table 6-17. A removal action is planned for the surface soil at the Site 3 SVOC AOC, so it is unlikely that exposure to Site 3 surface soil would result in adverse health effects.

6.4.3.3 Future Adult Residents in Site 1

Table 6-18 presents the carcinogenic and noncarcinogenic risks estimated for potential future on-site adult residents who may be exposed to COPCs in Site 1 surface soil, groundwater, surface water, and sediment. All total HI risks estimated for adults in this area under the RME exposure scenario, summed over all media, exceed USEPA acceptable criteria. Three total ICR values under the RME exposure scenario, summed over all media, exceed USEPA acceptable criteria. Total ICRs in exceedence ranged from 1.1×10^{-04} (well location 1GW12B, Cornwallis Cave aquifer) to 3.3×10^{-04} (Cornwallis Cave/Yorktown-Eastover aquifer) under RME scenarios. The total ICR that included the Columbia aquifer (7.8×10^{-05}) and Columbia aquifer-well location 1GW20, (6.5×10^{-05}) exposure scenarios were within USEPA's acceptable risk range. All total ICRs are within USEPA's target risk range when CT exposure scenarios are evaluated. Total HIs ranged from 1.3 (well location 1GW20, Columbia aquifer) to 3.1 (Columbia aquifer).

Surface Soil

Potential exposures to Site 1 surface soil COPCs via ingestion and dermal contact resulted in ICR and HI values within USEPA's target risk range when evaluating the RME and CT exposures, respectively.

Columbia Aquifer - Site 1

An estimation of the potential risks to future on-site adult residents subsequent to the ingestion, dermal contact, and inhalation of VOCs present in groundwater during showering, by averaging all Site 1 Columbia aquifer groundwater data (to produce 95%UCLs), resulted in an HI value of 1.4 and an ICR value of 3.5×10^{-05} (using organic and dissolved inorganic results). The ingestion route of exposure (HI = 2.8) accounted for approximately 96% of the total HI. The HI value derived exceeded the acceptable value of 1.0 mainly due to the presence of iron and manganese (which targets the central nervous system and lung). TCE (which affects the liver), arsenic (which targets the skin), and cadmium (which targets the renal cortex) also contribute to the elevated HI. Dissolved

iron accounted for 50 percent of the HI with an HQ of 1.3, while dissolved manganese accounted for 22 percent of the HI with an HQ of 0.59. TCE and arsenic accounted for 9 and 6 percent of the HI, respectively. Since TCE and the three analytes target different body organs/systems, their effects are not additive, indicating that only a slight potential exists for the occurrence of adverse effects.

Columbia Aquifer - Well 1GW20

An estimation of potential risks to future on-site adult residents subsequent to the ingestion, dermal contact, and inhalation of VOCs present in groundwater during showering, using the maximum concentration from Columbia aquifer monitoring well 1GW20, resulted in an HI value of 1.0 and an ICR value of 2.2×10^{-05} (using organic and dissolved inorganic results). It should be noted that the only detections among the Columbia aquifer COPCs at location 1GW20 were 1,2-DCE, TCE, and zinc. The ingestion of groundwater as drinking water contributed predominantly to the total HI value for this well location. The HI value exceeded the acceptable value of 1.0 due to the presence of TCE (targeting the liver) and 1,2-DCE (targeting whole body/blood). 1,2-DCE accounted for 15% of the ingestion HI (RME = 1.0; CT = 0.1), while TCE accounted for 84% of the ingestion HI. The ICR value is within the generally acceptable risk range of 1×10^{-06} to 1×10^{-04} when organic and dissolved (filtered) groundwater sample analytical results were used to determine the future potential human health effects associated with a potable groundwater use scenario.

Cornwallis Cave/Yorktown-Eastover Aquifer

An estimation of potential risk to future on-site adult residents subsequent to the ingestion, dermal contact, and inhalation of VOCs present in groundwater during showering, by averaging all Cornwallis Cave/Yorktown-Eastover aquifer groundwater data (to produce 95% UCLs), resulted in an RME HI value of 1.4 (CT HI = 0.4)and an ICR value of 2.8×10^{-04} (CT ICR = 3.3×10^{-05}) (using organic and dissolved inorganic results). The HI for the ingestion route of exposure (RME = 1.4; CT = 0.34) contributed the most predominantly to the groundwater HI at this location. Similarly, the ICR for the ingestion route (RME = 2.7×10^{-04}, CT = 3.1×10^{-05}) was the major contributor to the elevated groundwater ICR. The ingestion HI value exceeded the acceptable value of 1.0 due to the presence of 1,2-DCE contributing 23 percent of the HI value (targeting the blood) and TCE (targeting the liver) contributing 57% of the HI value. The ingestion ICR value (2.7×10^{-04})

exceeded the generally acceptable risk range of 1 x 10^{-06} to 1 x 10^{-04} due to the presence of vinyl chloride (individual ICR = 2.1 x 10^{-04}). 1,2-DCE and vinyl chloride are degradation products of TCE.

Cornwallis Cave/Yorktown-Eastover Aquifer - Well 1GW12B

Ingestion and dermal contact of COPCs in groundwater by future on-site adult residents, using the maximum detected concentration from monitoring well 1GW12B, resulted in an HI value of 1.9 and an ICR value of 6.1 x 10^{-05} (using organic and dissolved inorganic results). The HI for the ingestion route of exposure (RME = 1.8, CT = 0.2) contributed the most predominantly to the groundwater HI at this location. The elevated HI was due the presence of TCE (HQ = 1.6). The ICR value did not exceed the USEPA's target risk range of 1 x 10^{-06} to 1 x 10^{-04}.

Surface Water

Potential exposures to surface water COPCs via ingestion and dermal contact resulted in HI values less than 1.0 when evaluating the RME and CT exposures, respectively. Evaluating for carcinogenic risk did not apply in the case of surface water exposure since cadmium and iron were the only constituents retained as COPCs.

Sediment

Potential exposures to sediment COPCs via ingestion and dermal contact resulted in ICR values within USEPA's target risk range and HI values less than 1.0 when evaluating the RME and CT exposures, respectively.

6.4.3.4 Future Child Residents in Site 1

Table 6-17 also presents the carcinogenic and noncarcinogenic risks estimated for potential future on-site child residents who may be exposed to COPCs in Site 1 surface soil, groundwater, surface water, and sediment. All total HI risks estimated for young child residents in this area under the RME exposure scenario, summed over all media, exceed USEPA acceptable criteria. Only one total ICR under the RME exposure scenario, summed over all media, exceeded USEPA acceptable

criteria. The ICR in exceedence was 2.1 x 10^{-04} (Cornwallis Cave/Yorktown-Eastover aquifer). Total RME HIs ranged from 4.2 (well location 1GW20, Columbia aquifer) to 8.0 (Columbia aquifer). Total CT HIs ranged from 0.6 (well location 1GW20, Columbia aquifer) to 2.3 (Columbia aquifer).

Surface Soil

Except for the future residential child receptor, potential exposures to Site 1 surface soil COPCs via ingestion and dermal contact resulted in ICR and HI values within USEPA's target risk range when evaluating the RME and CT exposures, respectively. The total surface soil HI for the future residential child was 1.5. The ingestion route of exposure (HI = 1.1) accounted for over 90% of the total HI. This was due mainly to the presence of arsenic (67%) and iron (26%). However, it should be noted that the individual HQ values for arsenic and iron were below one (0.7 and 0.3, respectively). Also, while iron is evaluated quantitatively in this risk assessment, it is considered an essential nutrient, and the studies that prompted the addition of toxicity criteria are provisional only and have not been formally reviewed by the USEPA.

Columbia Aquifer

An estimation of potential risks to future on-site child residents subsequent to the ingestion and dermal contact of COPCs detected in the Columbia aquifer using the RME concentration for the Columbia aquifer, resulted in an HI of 6.3 and an ICR of 2.0 x 10^{-05} (using organic and dissolved inorganic results). The RME ingestion HI (6.2) contributed predominantly to the total groundwater HI. The ingestion HI value exceeded 1.0 due to the presence of dissolved iron and manganese (targeting the lung and central nervous system). Arsenic and cadmium also contribute to the elevated HI (9 and 6 percent, respectively). Iron accounted for 50 percent of the HI value while dissolved manganese accounted for 22 percent of the HI value. Since iron and manganese target different body organs/systems, their effects are not additive indicating the unlikelihood for the occurrence of adverse effects. The HI resulting from evaluation of the CT ingestion scenario was 1.9. The ICR value fell within the generally acceptable risk range of 1 x 10^{-06} to 1 x 10^{-04} when organic and dissolved inorganic groundwater sample analytical results were used to determine the future potential human health effects associated with potable groundwater use scenarios.

Columbia Aquifer - Well 1GW20

An estimation of potential risks to future on-site child residents subsequent to the ingestion and dermal contact of COPCs detected in shallow groundwater using the maximum concentration detected in the Columbia aquifer monitoring well 1GW20, resulted in an HI of 2.5 and an ICR of 1.2×10^{-05} (using organic and dissolved inorganic results). The ingestion HI (2.4) was the most predominant contributor to this elevated HI. The ingestion HI value exceeded 1.0 due to the presence of TCE (which targets the liver) and 1,2-DCE (targeting the blood) which contributed 84 percent and 15 percent, respectively, to the ingestion HI. TCE contributed 90 percent of the dermal HI. The ingestion HQ for TCE exceeded unity. The evaluation of CT scenarios resulted in a total groundwater HI of 0.3. The ICR value falls within the generally acceptable risk range of 1×10^{-06} to 1×10^{-04} when organic and dissolved inorganic groundwater sample analytical results were used to determine the future potential human health effects associated with potable groundwater use scenarios.

Cornwallis Cave/Yorktown-Eastover Aquifer

An estimation of potential risks to future on-site child residents subsequent to the ingestion and dermal contact of COPCs detected in the Cornwallis Cave/Yorktown-Eastover aquifer by averaging all Cornwallis Cave/Yorktown-Eastover aquifer groundwater data (to produce 95% UCLs), resulted in an HI of 3.3 and an ICR of 1.6×10^{-04} (using organic and dissolved inorganic results). The HI estimated for the ingestion (3.2) exceeded unity. The ingestion HI value exceeded the acceptable value of 1.0 due to the presence of TCE at 57 percent of the HI value and 1,2-DCE at 23 percent of the HI value. The HQ for TCE exceeded unity. When the CT scenarios were evaluated, the total groundwater HI became 1.1. The ingestion route of exposure (ICR = 1.6×10^{-04}) also contributes predominantly to the elevated ICR value. The ingestion ICR value exceeded the acceptable risk range due to the presence of vinyl chloride (individual ICR = 1.2×10^{-04}) When the CT scenarios were evaluated, the total groundwater HI (7.3×10^{-05}) was within acceptable criteria.

Cornwallis Cave/Yorktown-Eastover Aquifer - Well 1GW12B

Ingestion and dermal contact of COPCs in deep groundwater by future on-site child residents, using the maximum detected concentration, resulted in an HI value of 4.3 and an ICR value of 3.5×10^{-05}

(using organic and dissolved inorganic results). The RME ingestion HI (4.2) contributed predominantly to the total groundwater HI. The ingestion HI value exceeded 1.0 due to the presence of TCE (HQ = 3.8). The HI resulting from evaluation of the CT ingestion scenario (0.7) was within USEPA acceptable criteria. The ICR value did not exceed USEPA's target risk range of 1×10^{-06} to 1×10^{-04}.

Surface Water

Potential exposures to surface water COPCs via ingestion and dermal contact resulted in HI values less than 1.0 when evaluating the RME and CT exposures, respectively. Evaluating the potential carcinogenic risk did not apply in the case of surface water exposure since cadmium and iron were the only constituent retained as a COPC.

Sediment

Potential exposures to sediment COPCs via ingestion and dermal contact resulted in ICR values within USEPA's target risk range and HI values less than 1.0 when evaluating the RME and CT exposures, respectively.

6.4.3.5 Future Adult Residents in Site 3

Table 6-19 presents the carcinogenic and noncarcinogenic risks estimated for potential future on-site adult residents who may be exposed to COPCs in Site 3 surface soil, groundwater, surface water, and sediment. Total ICRs, summed over all media, ranged from 3.0×10^{-04} (averaged Cornwallis Cave/Yorktown-Eastover aquifer concentrations) to 3.6×10^{-03} (Cornwallis Cave/Yorktown-Eastover aquifer well location 3GW19 with SVOC AOC) under RME scenarios. Total RME HIs, summed over all media, ranged from 1.9 (averaged Cornwallis Cave/Yorktown-Eastover aquifer concentrations) to 8.0 (Cornwallis Cave/Yorktown-Eastover aquifer well location 3GW19 with SVOC AOC).

All carcinogenic and noncarcinogenic risks estimated for surface water and sediment pathways presented for future adult residents at Site 1 represent values applicable to both Site 1 and Site 3. As previously mentioned, this is because Sites 1 and 3 both lie along the headwaters of the surface

water body (e.g., Indian Field Creek) from which surface water/sediment samples were taken. Therefore, the risks associated with those media will not be reiterated for the future adult resident at Site 3. However, the following paragraph discusses potential risks to future adult residents associated with Site 3 surface soil and groundwater.

Surface Soil (without SVOC AOC)

Potential exposures to Site 3 surface soil (excluding the SVOC AOC) COPCs via ingestion and dermal contact resulted in ICR and HI values within USEPA's target risk range when evaluating the RME and CT exposures, respectively.

Surface Soil - SVOC AOC

Potential exposures to Site 3 SVOC AOC surface soil COPCs via ingestion and dermal contact resulted in a total HI exceeding unity when evaluating the RME exposures. The dermal contact route of exposure contributed approximately 86 percent of the total HI. This is due primarily to the presence of manganese (targeting the central nervous system and lung), contributing 77%. The HQ for manganese did not exceed unity. In addition, the total ICR value (2.6×10^{-03}) calculated for potential exposures to surface soil exceeded USEPA's acceptable risk range. Both the ingestion (2.3×10^{-04}) and the dermal (2.4×10^{-03}) exposure pathways exceeded the acceptable risk range. This is due primarily to the presence of benzo(a)pyrene. It should be noted that a removal action is planned for the SVOC AOC, and it is unlikely that exposure to Site 3 surface soil would cause adverse health effects.

Cornwallis Cave/Yorktown-Eastover Aquifer

An estimation of potential risks to future on-site adult residents subsequent to the ingestion, dermal contact, and inhalation of VOCs present in groundwater during showering, by averaging all Cornwallis Cave/Yorktown-Eastover aquifer groundwater data (to produce 95% UCLs), resulted in an HI of 1.4 and an ICR of 2.8×10^{-04} (using organic and dissolved inorganic results). The HI estimated for the ingestion (1.4) exceeded unity. The ingestion HI value exceeded the acceptable value of 1.0 due to the presence of TCE at 57 percent of the HI value and 1,2-DCE at 23 percent of the HI value. The HQs for these COPCs did not exceed unity. When the CT scenarios were

evaluated, the ingestion HI and the total groundwater HI were within acceptable criteria. The ingestion route of exposure (ICR = 2.7 x 10^{-04}) also contributes predominantly to the elevated total ICR value. The ingestion ICR value exceeded the acceptable risk range due to the presence of vinyl chloride at 78% of the ICR. When the CT scenarios were evaluated, both the ingestion and total groundwater ICRs were within USEPA's target risk range.

Cornwallis Cave/Yorktown-Eastover Aquifer - Well 3GW19

An estimation of potential risks to future on-site residents subsequent to the ingestion, dermal contact, and inhalation of VOCs present in groundwater during showering, using the maximum detected concentration from monitoring well 3GW19, resulted in an HI value of 6.1 and an ICR value of 1.0 x 10^{-03} (using organic and dissolved inorganic results). The RME ingestion HI (5.9) contributed predominantly to the total groundwater HI. The ingestion HI value exceeded 1.0 due to the presence of TCE and 1,2-DCE at 66% and 29%, respectively. The HI resulting from evaluation of the CT ingestion scenario was less than unity. The RME ingestion ICR (9.7 x 10^{-04}) contributed predominantly to the total groundwater ICR. The ingestion ICR value exceeded the acceptable risk range due to the presence of vinyl chloride at 88% The ICR resulting from evaluation of the CT ingestion scenario was within USEPA's target risk range. Vinyl chloride and 1,2-DCE are potential degradation products of TCE.

6.4.3.6 Future Child Residents in Site 3

Table 6-19 also presents the carcinogenic and noncarcinogenic risks estimated for potential future on-site child residents who may be exposed to COPCs in Site 3 surface soil, groundwater, surface water, and sediment. All total ICR exceeded USEPA's target risk range. The ICR values ranged from 1.8 x 10^{-04} (averaged Cornwallis Cave/Yorktown-Eastover aquifer concentrations) to 2.1 x 10^{03} (well location 3GW19 with SVOC AOC) under the RME scenarios. Total RME HIs ranged from 5.1 (averaged Cornwallis Cave/Yorktown-Eastover aquifer concentrations) to 20 (well location 3GW19 with SVOC AOC). Total CT HIs ranged from 1.3 (well location 3GW19) to 3.6 (averaged Cornwallis Cave/Yorktown-Eastover aquifer concentrations with SVOC AOC).

All carcinogenic and noncarcinogenic risks estimated for surface water and sediment pathways presented for future child residents at Site 1 represent values applicable to both Site 1 and Site 3.

As previously mentioned, this is because both sites are located along the surface water body (e.g., Indian Field Creek) from which surface water/sediment samples were taken. Therefore, the risks associated with those media will not be reiterated for the future child resident at Site 3. However, the following paragraph discusses potential risks to future child residents associated with Site 3 surface soil and groundwater.

Surface Soil (without SVOC AOC)

Potential exposures to Site 3 surface soil (excluding the SVOC AOC) COPCs via ingestion and dermal contact resulted in an ICR value within USEPA's target risk range when evaluating the RME and CT exposures, respectively. The total HI for future residential children was 1.6. The elevated HI is due primarily to the ingestion pathway (HI=0.99). Iron contributed approximately 50% of the ingestion pathway HI. It should be noted that each individual HQ was less than one and when evaluating the CT exposures, the total HI was less than one. This indicates that adverse health effects are unlikely. Also, iron is considered an essential nutrient, and the studies that prompted the addition of toxicity criteria are provisional and have not been reviewed by the USEPA.

Surface Soil - SVOC AOC

Potential exposures to Site 3 SVOC AOC surface soil COPCs via ingestion and dermal contact resulted in a total HI exceeding unity when evaluating the RME exposures. The dermal contact route of exposure contributed approximately 52 percent of the total HI. This is due primarily to the presence of manganese (targeting the central nervous system and lung), contributing 77%. In addition, the total ICR value (1.5×10^{-03}) calculated for potential exposures to surface soil exceeded USEPA's acceptable risk range. Both the ingestion (5.4×10^{-04}) and the dermal (1.0×10^{-03}) exposure pathway exceeded the acceptable risk range. This is due primarily to the presence of benzo(a)pyrene. It should be noted that a removal action is planned for Site 3 SVOC AOC. It is unlikely that exposure to Site 3 surface soils would cause adverse health effects.

Cornwallis Cave/Yorktown-Eastover Aquifer

An estimation of potential risks to future on-site child residents subsequent to the ingestion, dermal contact, and inhalation of VOCs present in groundwater during showering, by averaging all

Cornwallis Cave/Yorktown-Eastover aquifer groundwater data (to produce 95% UCLs), resulted in an HI of 3.3 and an ICR of 1.6×10^{-04} (using organic and dissolved inorganic results). The HI estimated for the ingestion (3.2) exceeded unity. The ingestion HI value exceeded the acceptable value of 1.0 due to the presence of TCE at 57 percent of the HI value and 1,2-DCE at 23 percent of the HI value. The HQ for TCE exceeded unity. When the CT scenarios were evaluated, the ingestion HI became 1.1 and the total groundwater HI became 1.2. The ingestion route of exposure (ICR = 1.6×10^{-04}) also contributes predominantly to the elevated total ICR value. The ingestion ICR value exceeded the acceptable risk range due to the presence of vinyl chloride at 78% of the ICR.

Cornwallis Cave/Yorktown-Eastover Aquifer - Well 3GW19

An estimation of potential risks to future on-site residents subsequent to the ingestion, dermal contact, and inhalation of VOCs present in groundwater during showering, using the maximum detected concentration from monitoring well 3GW19, resulted in an HI value of 14 and an ICR value of 5.7×10^{-04} (using organic and dissolved inorganic results). The RME ingestion HI (14) contributed predominantly to the total groundwater HI. The ingestion HI value exceeded 1.0 due to the presence of TCE (HQ = 9.2) and 1,2-DCE (HQ = 4.0). The HI resulting from evaluation of the CT ingestion scenario was within USEPA's acceptable criteria. The RME ingestion ICR (5.6×10^{-04}) contributed predominantly to the total groundwater ICR. The ingestion ICR value exceeded the acceptable risk range due to the presence of vinyl chloride (individual ICR = 5.0×10^{-04}). The ICR resulting form evaluation of the CT ingestion scenario falls within USEPA's target risk range.

6.4.3.7 Future Construction Workers at Site 1

The ICRs and HIs were estimated for future construction workers who may be potentially exposed to subsurface soil, during excavation and construction activities, via the pathways of accidental ingestion, dermal contact and the inhalation of fugitive dusts. Because no unacceptable risks resulted for future construction workers at Site 1, only RME scenarios were evaluated. These scenarios are not discussed, but are presented in Appendix 6E.

6.4.3.8 Future Construction Workers at Site 3

Table 6-20 presents the ICRs and HIs that were estimated for future construction workers who may be potentially exposed to subsurface soil, during excavation and construction activities, via the pathways of accidental ingestion, dermal contact and the inhalation of fugitive dusts. The total ICR evaluated for exposure to subsurface soil was within USEPA's target risk range. However, the total HI was 1.6. The ingestion pathway (HI=1.1) contributed approximately 69% of the total HI. This was due primarily to the presence of iron (HQ=0.76), which contributed 70 percent of the ingestion pathway HI. If iron were removed from the risk calculations, the total HI would fall below one. It should be noted that iron is considered an essential nutrient, and the studies that prompted the addition of toxicity criteria are provisional and have not been reviewed by the USEPA.

6.5 Sources of Uncertainty

Uncertainties are encountered throughout the process of performing a risk assessment. This section discusses the sources of uncertainty inherent in the following elements of the human health evaluation performed for Sites 1 and 3:

- Sampling and analysis
- Selection of COPCs
- Exposure assessment
- Toxicity assessment
- Risk characterization
- Chemicals not quantitatively evaluated

Uncertainties associated with this risk assessment are discussed in the following paragraphs. Table 6-19 summarizes the potential effects of certain uncertainties on the estimation of human health risks.

6.5.1 Sampling and Analysis

The development of a risk assessment depends on the reliability of, and uncertainties associated with, the analytical data available to the risk assessor. These, in turn, are dependent on the operating

procedures and techniques applied to the collection of environmental samples in the field and their subsequent analyses in the laboratory. To minimize the uncertainties associated with sampling and analysis at Sites 1 and 3, USEPA approved sampling and analytical methods were employed. Data was generated following USEPA's Statement of Work for Contract Laboratory Program (CLP). Samples were analyzed for TCL organics (plus nitramine compounds), TAL inorganics, and cyanide. Samples were taken from locations specified in the approved Work Plan along with the necessary QA/QC samples.

Analytical data are limited by the precision and accuracy of the methods of analysis which are reflected by the Relative Percent Difference (RPD) of duplicate analyses and the percent recovery of spikes, respectively. In addition, the statistical methods used to compile and analyze the data (mean concentrations, detection frequencies) are subject to the overall uncertainty in data measurement. Furthermore, chemical concentrations in environmental media fluctuate over time and with respect to sampling location. Analytical data must be sufficient to consider the temporal and spatial characteristics of contamination at the site with respect to exposure.

6.5.2 Selection of COPCs

The selection of COPCs is performed in a risk assessment following the evaluation of data. Analytical data also must be comprehensive in order to address the COPCs associated with the site. Types of COPCs encountered at Sites 1 and 3 include some VOCs (in Site 3 surface soil, the Columbia aquifer, the Cornwallis Cave/Yorktown-Eastover aquifer, and sediment), SVOCs (surface soil in both sites, Site 1 subsurface soil, and the Columbia aquifer), and a nitramine (in the Columbia aquifer). Inorganic constituents were detected in every medium investigated; they were the most dominant class of chemicals detected at Sites 1 and 3. A summary of the COPC selection criteria is presented below.

- Soil COPCs were selected based on comparisons of the maximum detected concentration with Region III residential soil COC values.

- Groundwater COPCs were selected based on comparisons of the maximum detected concentration with Region III tap water COC values, Federal MCLs, and Commonwealth groundwater standards.

- Surface water COPCs were selected based on comparisons of the maximum detected concentration to Federal and Commonwealth Water Quality Criteria as well as Region III tap water COC values.

- Sediment COPCs were selected based on comparisons of the maximum detected concentration to SSVs and Region III residential soil COC values.

Region III COC values are based on exposure assumptions and equations that are intended to introduce conservatism in the risk assessment process by changing the COPC screening method from a relative toxicity screen as presented in RAGS, to an absolute comparison of risk. However, the use of the Region III COC values which incorporate a set of non-site-specific assumptions in the selection of COPCs at Sites 1 and 3, adds conservatism to the baseline RA. Furthermore, the use of SSV ER-Ms (which are intended for aquatic organisms) and residential soil COC values (which are intended for soil not sediment) in the selection of human health COPCs, provides a very conservative screening tool.

It should be noted that PAHs, both carcinogenic and noncarcinogenic, were detected in the surface and subsurface soils at Sites 1 and 3. It is known that PAHs do not occur alone, but rather, as mixtures. In some instances, PAHs can be re-included as COPCs even though they did not exceed screening criteria. However, in this RA only those PAHs that exceeded screening criteria were retained as COPCs. Of the carcinogenic PAHs, benzo(a)pyrene is considered the most potent and has the most conservative toxicity criteria (e.g., CSF and RBCs). Furthermore, the toxicity criteria for the other cPAHs is based on the values determined for benzo(a)pyrene through research. Consequently, benzo(a)pyrene was retained as a COPC (if it exceeded screening criteria) to represent a conservative approach. In addition, any other PAH that exceeded criteria was retained.

Currently, no Station closures are planned for WPNSTA Yorktown and future residential development is not considered an expected land use for the area. The application of the residential COC values to soil and groundwater COPC selections would, therefore, tend to result in a list of COPCs that could be considered conservative for a military base. The use of conservative COPC selections in the baseline RA ensures the protection of public health in that the results of the baseline

RA are incorporated into the determination of remedial alternatives and remedial action objectives in the FS.

6.5.3 Exposure Assessment

In performing exposure assessments, uncertainties arise from two main sources. First, uncertainties arise in estimating the fate of a compound in the environment, including estimating release and transport in a particular environmental medium. Second, uncertainties arise in the estimation of chemical intakes resulting from contact by a receptor with a particular medium.

To estimate an intake, certain assumptions must be made about exposure events, exposure durations, and the corresponding assimilation of constituents by the receptor. Exposure factors have been generated by the scientific community and have undergone review by the USEPA. The USEPA has published an Exposure Factors Handbook (USEPA, 1989a) which contains the best and latest values. Regardless of the validity of these exposure factors, they have been derived from a range of values generated by studies of limited numbers of individuals. In all instances, values used in this risk assessment, scientific judgments, and conservative assumptions agree with those of the USEPA.

The use of a RME approach, designed as not to underestimate daily intakes, was employed throughout this risk assessment. The use of 95% UCL estimates of the arithmetic mean versus maximum values as the concentration term in estimating the CDI or DAD for soil, shallow groundwater, surface water and sediment exposure scenarios reduces the potential for underestimating exposure at Sites 1 and 3.

The use of the maximum concentration as the exposure point concentration for the three groundwater monitoring wells, in estimating the DAD or CDI for future groundwater usage, was selected based upon the distribution of the highest concentration of contamination at the sites. Although the use of source "hot spot" monitoring wells may result in an overestimation of potential risks associated with the site, this may be offset by groundwater COPCs reported as nondetects, that could not be evaluated. Therefore, the exposure point concentrations selected causes the estimation of CDIs and DADs to err on the side of health conservatism.

Uncertainties also arise in the estimation of chemical intakes resulting from contact by a receptor with a particular medium. An example of uncertainty introduced by the latter source is the estimation of potential intakes to construction workers as a result of direct contact exposures to subsurface soil during excavation/construction activities. Here, the uncertainty lies in the assumption that the only medium of concern for this receptor is subsurface soil. Construction worker exposures to surface soil could also occur; however, it is assumed in this HHRA that at surface soil exposures are insignificant at an excavated construction site relative to subsurface soil exposures. Intakes due to direct contact exposures to surface soil were estimated for the much more conservative residential scenario. The resulting residential risks are expected to be greater than those that would be estimated for the construction worker scenario, and would most likely drive the surface soil remedial efforts.

6.5.4 Toxicological Assessment

In making quantitative estimates of the toxicity of varying dosages of compounds to human receptors, uncertainties arise from two sources. First, data on human exposure and the subsequent effects are usually insufficient, if they are at all available. Human exposure data usually lack adequate concentration estimations and suffer from inherent temporal variability. Therefore, animal studies are often used and new uncertainties arise from the process of extrapolating animal results to humans. Second, to obtain observable effects with a manageable number of experimental subjects, high doses of a compound are often used. In this situation, a high dose means that high exposures are used in the experiment with respect to most environmental exposures. Therefore, when applying the results of the animal experiment to the human condition, the effects at the high doses must be extrapolated to approximate effects at lower doses.

In extrapolating effects from high doses in animals to low doses in humans, scientific judgment and conservative assumptions are employed. In selecting animal studies for use in dose-response calculations, the following factors are considered:

- Studies are preferred where the animal closely mimics human pharmacokinetics.
- Studies are preferred where dose intake most closely mimics the intake route and duration for humans.

- Studies are preferred which demonstrate the most sensitive response to the compound in question.

For compounds believed to cause threshold effects (i.e., noncarcinogens) safety factors are employed in the extrapolation of effects from animals to humans and from high doses to low doses. In deriving carcinogenic potency factors, the 95% UCL value is promulgated by the USEPA to prevent underestimation of potential risk.

Further conservatism in the baseline RA is also introduced through the use of experimentally-derived oral absorption efficiencies to account for a difference in the degree of toxicity between an administered dose and an absorbed dose. Equating the absorption efficiency of the dermal bi-phasic barrier to the absorption efficiency of the gastrointestinal lining is a very conservative approach that tends to overestimate the potential risk to human health.

Recently, the element iron was given a RBC value and toxicity values with which to evaluate potential human health risks. However, iron is still considered an essential nutrient. Also, the studies that prompted the addition of a RBC value for iron are provisional only and have not undergone formal review by the USEPA. For these reasons, the selection of iron as a COPC for evaluation in human health risk assessments is associated with some uncertainty. However, by evaluating iron in the risk assessment, a conservative approach is taken and potential toxic effects are not expected to be underestimated.

In summary, the use of conservative assumptions, results in quantitative indices of toxicity that are not expected to underestimate potential toxic effects, but may overestimate these effects by an order of magnitude or more.

6.5.5 Human Risk Characterization

The risk characterization bridges the gap between potential exposure and the possibility of systemic or carcinogenic human health effects, ultimately providing impetus for the remediation of the site or providing a basis for no remedial action.

Uncertainties associated with risk characterization include the assumption of chemical additivity and the inability to predict synergistic or antagonistic interactions between COPCs. These uncertainties are inherent in any inferential risk assessment. USEPA promulgated inputs to the quantitative risk assessment and toxicological indices are calculated to be protective of the human receptor and to err conservatively, so as to not underestimate the potential human health risks.

6.5.6 Compounds Not Quantitatively Evaluated

No risk levels were quantitatively estimated for carbazole or lead in the baseline RA. Carbazole, which no longer has toxicity criteria, was retained as a COPC in Site 3 surface soil. Lead was retained as a COPC in total inorganics in the Cornwallis Cave/Yorktown-Eastover aquifer and in Sites 1 and 3 sediment. However, total inorganics are assumed to represent suspended solids and total inorganic COPCs are not quantitatively evaluated in groundwater exposure scenarios. Also, the lead UBK model was not used to evaluate health effects of lead exposure from sediment since the model does not include that medium.

Lead is currently considered a B2 - probable human carcinogen, as well as a developmental toxin in young children. The lack of promulgated toxicological indices for lead does not have significant effects on the underestimation of risk due to the presence of relatively high levels of other COPCs in environmental media, such as arsenic. This risk assessment has been performed using conservative exposure point concentrations, exposure scenarios (use of the groundwater aquifer as a drinking water source), and available toxicological information.

6.6 Summary of Risk Assessment Results

This section summarizes the results of the baseline RA and identifies environmental media and COPCs which could potentially pose human health risks and/or effects. Potential carcinogenic and noncarcinogenic human health risks were estimated for human receptors under RME exposure scenarios previously identified in Section 6.2.1. For each receptor, total risks were estimated by site for on-Station current trespassers, future residential receptors, and future construction workers. It should be noted that risks due to surface and subsurface soil were calculated by site, while risks due to groundwater were separated further by aquifer. Risks associated with surface water and sediment were estimated over both sites, and were summed with surface soil and groundwater risks for each

site. Groundwater risks were also estimated for three individual well locations: 3GW19 and 1GW12B from the Cornwallis Cave/Yorktown-Eastover aquifer and 1GW20 from the Columbia aquifer. Risks associated with these individual well exposures were estimated from maximum detected concentrations. Groundwater risks were summed with the other three media for each site under future residential scenarios. Future construction workers were evaluated only for subsurface soil exposures for each site.

In addition, due to the conservative nature of the RME evaluation of future residential land use, residential risks were also evaluated under a set of exposure concentrations and assumptions that approximates CT. CT risks are represented in all residential risk characterization tables by the values presented in parentheses. The following paragraphs present the potential current and future exposure pathways and the subsequent potential total site risk to humans.

6.6.1 Current Potential Receptors

Potential current receptors to COPCs detected in environmental media at Sites 1 and 3 include:

- Adolescent on-Station trespassers (7-15 years old)
- Adult on-Station trespassers

The total ICR values previously presented in Table 6-15 for the current adult and adolescent on-Station trespassers at Site 1 fall within the USEPA's generally acceptable target risk range of 1×10^{-06} to 1×10^{-04}. The target risk range represents the range of potential risks that USEPA generally believes to be acceptable. HI values presented in Table 6-15 for current potential human receptors in both Site 1 and Site 3 fall below 1.0, indicating that noncarcinogenic adverse human health risks will probably not occur subsequent to exposure.

The total ICR values presented in Table 6-15 for the current adult and adolescent on-Station trespassers at Site 3 exceed the USEPA's generally acceptable target risk range of 1×10^{-06} to 1×10^{-04}. This is due to potential exposure to the Site 3 SVOC AOC surface soil. However, a removal action is planned for this "hot spot" area, so it is unlikely that adverse health effects would result from exposure to Site 3 surface soils. When the SVOC AOC is removed from the risk calculations, the risks are within acceptable levels.

6.6.2 Future Potential Receptors

Property use at Sites 1 and 3 will remain the same in the foreseeable future. Future residential development of these sites is highly unlikely given their location within an area encumbered by the ESQD arc, which prohibits its development as Station housing. However for the sake of conservatism, future residential land use and associated potential risks were evaluated for each area of concern. The potential human receptors evaluated under the future scenarios were:

- Future adult residents
- Future young child residents (1-6 years old)
- Future adult construction workers

As stated previously, due to the conservative nature of the risk assessment for residential land use [redacted] exposures.

Table 6-16 previously presented the summary of the total ICR and HI values for the future receptors for each area of concern and each potable source scenario. Table 6-16 presents total residential lifetime risks resulting from summing over adult and child risks for each site and potable source scenario, as well as the carcinogenic and noncarcinogenic risks to the future construction worker for both sites. Risks calculated for the future construction worker for Site 1 were within acceptable levels. However, the noncarcinogenic risk for the future construction worker for Site 3 exceeded unity. As can be seen from Table 6-16, RME carcinogenic and noncarcinogenic residential risks exceed acceptable criteria for all scenarios. Under CT scenarios, Table 6-16 shows that all but one total carcinogenic risk for Site 3, in addition to total carcinogenic risk in one of the four potable source scenarios for Site 1, exceed USEPA acceptable risk criteria. Also, all HIs under the CT scenario exceed acceptable criteria except for one potable source scenario in Site 1. A discussion of the results for each of these scenarios is presented below.

Future Residents

It was assumed that future (adult and child) residents could potentially be exposed to COPCs in surface soil, groundwater, surface water, and sediment. Even though the future development of groundwater for potable purposes is unlikely, given the availability of municipal water, potential potable exposure to COPCs in groundwater was evaluated for the sake of conservatism. Table 6-16 presents the total ICR and HI values for the future potential residential development of Sites 1 and 3 (residents and construction workers). The table presents total ICR and HI values for future adult and child residents as individual receptors.

Total ICR values estimated for RME residential receptors exceeded the USEPA's target risk range of 1×10^{-06} to 1×10^{-04} in both Site 1 and Site 3. This was due primarily to the contaminants detected in the groundwater medium. Exceedences of the target risk range in Site 1 and Site 3 occurred based on the location of the groundwater receptor locations being considered. In Site 3, exceedences by total ICRs occurred when evaluating the Cornwallis Cave/Yorktown-Eastover aquifer and the designated well location. In the case of the Columbia aquifer groundwater receptor scenarios (averaged and location 1GW20) for Site 1, the individual ICRs fell within USEPA's acceptable risk range. In addition, the individual ICR for the Site 1 Cornwallis Cave well location 1GW12B was within the target risk range. In the case of the Cornwallis Cave/Yorktown-Eastover aquifer groundwater receptor scenarios (averaged) for Sites 1 and 3 and 3GW19 for Site 3, the ICRs for adult and child exceeded the acceptable target risk range. For the groundwater scenarios in both sites, the presence of vinyl chloride (a potential degradation product of TCE) in the Cornwallis Cave/Yorktown-Eastover aquifer contributed the most to exceedences of the target risk range. Also, vinyl chloride was not detected in Station background (Baker, 1995).

The ICR value estimated for RME residential receptors exposed to Site 3 SVOC AOC surface soil exceeded the USEPA's target risk range of 1×10^{-06} to 1×10^{-04}. This is due primarily to the presence of benzo(a)pyrene. However, it should be noted that a removal action is planned for this "hot spot" area. If the SVOC AOC is removed from the risk calculations, the surface soil ICR values fall within acceptable levels.

HI values for future resident adults and children were greater than 1.0, suggesting that noncarcinogenic adverse health effects may occur subsequent to exposure. For the most part,

elevated total HI values were due to contaminants detected in the two aquifers. Ingestion of and dermal contact with arsenic and iron resulted in an unacceptable HI for surface soil (1.5) in Site 1 for the future child resident. At Site 3, ingestion of and dermal contact with iron, manganese, arsenic, and antimony in surface soil (excluding SVOC AOC) resulted in an unacceptable HI for future child residents (1.6). It should be noted that the individual pathway HIs for either site did not exceed unity. Site 1 surface soil concentrations of arsenic exceeded corresponding maximum detected Station background concentrations. Site 3 surface soil concentrations of manganese and antimony exceeded corresponding Station background, while arsenic did not.

In the Columbia aquifer groundwater receptor scenarios for Site 1 (averaged), dissolved manganese and TCE were the main contributors to the total HI value; whereas, in the Columbia aquifer groundwater receptor scenarios for 1GW20, TCE and 1,2-DCE were the main contributors to the total HI value. In the Cornwallis Cave/Yorktown-Eastover aquifer groundwater receptor scenarios for Site 1 (averaged), TCE and 1,2-DCE were the main contributors to the total HI value. In the Cornwallis Cave/Yorktown-Eastover aquifer groundwater scenario for 1GW12B, TCE is the primary contributor to the elevated HI. TCE and 1,2-DCE were not detected in Station shallow background (Baker, 1995). The maximum detected dissolved manganese concentration exceeded the maximum detected Station background concentration. In the Cornwallis Cave/Yorktown-Eastover aquifer groundwater receptor scenarios for Site 3 (averaged) and 3GW19, TCE and 1,2-DCE were the main contributors to total HI values.

6.7 References

Baker Environmental, Inc. 1995. Summary of Background Constituent Concentrations and Characterization of the Biotic Community from the York River Drainage Basin. July, 1995

Baker Environmental, Inc. 1994. Final Work Plan for Sites 6, 7, 12, 16, Site Screening Area 16, and Background, Naval Weapons Station Yorktown, Yorktown, Virginia. June, 1994.

Bureau of National Affairs, Inc. 1994. Environment Reporter-State Water Laws. Volume 6. Washington, D.C.

Clement Associates, Inc. 1985. Chemical, Physical, and Biological Properties of Compounds Present at Hazardous Waste Sites. Final Report.

Cowherd et al., 1985. Rapid Assessment of Exposure to Particulate Emissions from Surface Contamination. Prepared by Midwest Research Institute, Washington, D.C. EPA/600/8-85-002.

Department of the Navy (DoN). 1991. The Master Plan for the U.S. Naval Weapons Station, Yorktown. Atlantic Division, Naval Facilities Engineering Command, Norfolk, Virginia.

Foster, Sarah A. and Paul C. Chrostowski, 1987. Inhalation Exposures to Volatile Organic Contaminants in the Shower. ICF-Clement Associates, Inc. Washington, D.C.

Gilbert, Richard O. 1987. Statistical Methods for Environmental Pollution Monitoring. Van Nostrand Reinhold, New York, New York.

Long, Edward R., Donald D. MacDonald, Sherri L. Smith, and Fred D. Calder. 1995. "Incidence of Adverse Biological Effects Within Ranges of Chemical Concentrations in Marine and Estuarine Sediment," Environmental Management, Vol. 19, No. 1, PP. 81-97. Springer-Verland New York Inc.

United States Environmental Protection Agency. 1996. Drinking Water Regulations and Health Advisories. Office of Water U.S. Environmental Protection Agency. Washington, D.C. February, 1996.

United States Environmental Protection Agency. 1996a. Integrated Risk Information System. Environmental Criteria and Assessment Office, Cincinnati, Ohio.

United States Environmental Protection Agency. 1996b. "Risk-Based Concentration Summary Table", January - June, 1996. Region III, Philadelphia, Pennsylvania.

United States Environmental Protection Agency. 1995a. Assessing Dermal Exposure from Soil. Hazardous Waste Management Division, Office of Superfund Programs. Region III, Philadelphia, Pennsylvania. December 1995.

United States Environmental Protection Agency. 1995b. Health Effects Summary Tables Annual FY 1994. Office of Solid Waste and Emergency Response, Washington, D.C. May 1995. OERR 9200.6-303(95-1).

United States Environmental Protection Agency. 1994a. COC Screening Table, Region III Supplementary Risk Assessment Guidance for Superfund. Region III, Philadelphia, Pennsylvania. March 1994.

United States Environmental Protection Agency. 1994b. Revised Soil Lead Guidance for CERCLA Sites and Corrective Action Facilities. OSWER Directive 9355.4-12, July 14, 1994.

United States Environmental Protection Agency. 1993a. Selecting Exposure Routes and Contaminant of Concern by Risk-Based Screening. Region III Technical Guidance Manual. Region III, Philadelphia, Pennsylvania. January 1993. EPA/903/R-93-001.

United States Environmental Protection Agency. 1993b. Superfund's Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure. Draft. Washington, D.C. November 4, 1993.

United States Environmental Protection Agency. 1992a. Dermal Exposure Assessment: Principles and Applications. Interim. Office of Research and Development. Washington, D.C. January 1992. EPA/600/8-91/011B.

United States Environmental Protection Agency. 1992b. Risk Assessment Guidance for Superfund Volume I, Human Health Evaluation Manual Supplemental Guidance. Dermal Risk Assessment. Interim Guidance. Office of Emergency and Remedial Response. Washington, D.C. August 18, 1992.

United States Environmental Protection Agency. 1992c. New Interim Region IV Guidance. USEPA Region IV, Atlanta, Georgia. February 10, 1992.

United States Environmental Protection Agency. 1992d. Supplemental Guidance to RAGS: Calculating the Concentration Term. OSWER Publication Number 9285.7-081. May 1992.

United States Environmental Protection Agency. 1991a. Risk Assessment Guidance for Superfund Volume I. Human Health Evaluation Manual Supplemental Guidance: "Standard Default Exposure Factors" Interim Final. Office Solid Waste and Emergency Response. Washington, D.C. March 25, 1991. OSWER Directive 9285.6-03.

United States Environmental Protection Agency. 1991b. Risk Assessment Guidance for Superfund Volume I. Human Health Evaluation Manual (Part B) (Development of Risk-Based Preliminary Remediation Goals). Interim. Office Solid Waste and Emergency Response. Washington, D.C. December, 1991. OSWER Directive 9285.7-01B.

United States Environmental Protection Agency. 1990. National Oil and Hazardous Substances Pollution Contingency Plan; Final Rule. Federal Register, 40 Code of Federal Regulations Part 300, March 8, 1990.

United States Environmental Protection Agency. 1989a. Exposure Factors Handbook. Office of Health and Environmental Assessment. Washington, D.C. July 1989. EPA/600/8-89-043.

United States Environmental Protection Agency. 1989b. Risk Assessment Guidance for Superfund Volume I. Human Health Evaluation Manual (Part A) Interim Final. Office of Solid Waste and Emergency Response. Washington, D.C. December 1989. EPA/540/1-89-002.

United States Environmental Protection Agency. 1988. Superfund Exposure Assessment Manual. Office of Emergency and Remedial Response. Washington, D.C. April 1988. EPA/540/1-88/001 and OSWER Directive 9285.5-1.

Verschueren, Karel. 1983. Handbook of Environmental Data on Organic Chemicals. Van Nostrand Reinhold Company, Inc. New York, New York.

TABLES

TABLE 6-1

SUMMARY OF ORGANIC BLANK CONTAMINANT RESULTS
SITES 1 AND 3
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Organic Compound Detected in Blank	Maximum Concentration Detected in Blank (µg/L)	Type of Blank with Maximum Detected Value	Concentration for Comparison (Aqueous-µg/L)	Concentration for Comparison[3] (Solid-µg/kg)
VOCs: Chloroform	51	Field Blank	255[1]	255
1,2-Dichloroethene(total)	5J	Field Blank	25[1]	25
2-Butanone	44	Rinsate Blank	440[2]	440
Bromodichloromethane	8J	Field Blank	40[1]	40
Acetone	21	Trip Blank	210[2]	210
Trichloroethene	100	Field Blank	500[1]	500
Tetrachloroethene	3J	Field Blank	15[1]	15
Toluene	3J	Rinsate Blank	30[1]	30
SVOCs: Phenol	18	Field Blank	90[1]	2,970
2-Methylphenol	4J	Field Blank	20[1]	660
1,2,4-Trichlorobenzene	2J	Field Blank	10[1]	330
2,6-Dinitrotoluene	3J	Rinsate Blank	15[1]	495
Diethylphthalate	10	Rinsate Blank	100[2]	3,300
Di-n-butylphthalate	22	Rinsate Blank	220[2]	7,260
Bis(2-ethylhexyl)phthalate	460	Rinsate Blank	4,600[2]	151,800

Notes:

[1] Compound is not a common laboratory contaminant. Concentration for comparison is five times the maximum detected concentration.
[2] Compound is a common laboratory contaminant. Concentration for comparison is ten times the maximum detected concentration.
[3] Concentration is five times or ten times the maximum detected concentration in a blank; converted to µg/kg.

TABLE 6-1

SUMMARY OF ORGANIC BLANK CONTAMINANT RESULTS
SITES 1 AND 3
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Organic Compound Detected in Blank	Maximum Concentration Detected in Blank (µg/L)	Type of Blank with Maximum Detected Value	Concentration for Comparison (Aqueous-µg/L)	Concentration for Comparison[3] (Solid-µg/kg)
VOCs: Chloroform	51	Field Blank	255[1]	255
1,2-Dichloroethene(total)	5J	Field Blank	25[1]	25
2-Butanone	44	Rinsate Blank	440[2]	440
Bromodichloromethane	8J	Field Blank	40[1]	40
Acetone	21	Trip Blank	210[2]	210
Trichloroethene	100	Field Blank	500[1]	500
Tetrachloroethene	3J	Field Blank	15[1]	15
Toluene	3J	Rinsate Blank	30[1]	30
SVOCs: Phenol	18	Field Blank	90[1]	2,970
2-Methylphenol	4J	Field Blank	20[1]	660
1,2,4-Trichlorobenzene	2J	Field Blank	10[1]	330
2,6-Dinitrotoluene	3J	Rinsate Blank	15[1]	495
Diethylphthalate	10	Rinsate Blank	100[2]	3,300
Di-n-butylphthalate	22	Rinsate Blank	220[2]	7,260
Bis(2-ethylhexyl)phthalate	460	Rinsate Blank	4,600[2]	151,800

Notes:

(1) Compound is not a common laboratory contaminant. Concentration for comparison is five times the maximum detected concentration.
(2) Compound is a common laboratory contaminant. Concentration for comparison is ten times the maximum detected concentration.
(3) Concentration is five times or ten times the maximum detected concentration in a blank; converted to µg/kg.

TABLE 6-2

SURFACE SOIL DATA AND COPC SELECTION SUMMARY
SITE 1
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Contaminant[1]	Region III Criteria[2]	Contaminant Frequency/Range[3]		Background[4]		Comparison to Criteria	COPC Selection
	Residential COC Value (mg/kg)	No. of Positive Detects/ No. of Samples	Range of Positive Detections (mg/kg)	No. of Positive Detects/ No. of Samples	Range of Positive Detections (mg/kg)	Positive Detects Above Residential COC Value	Selected as a COPC?
Semivolatiles:							
Acenaphthylene	230[5]	1/21	0.046J	0/13	ND	0	No
2,4-Dinitrotoluene	16	1/21	0.068J	0/13	ND	0	No
Diethylphthalate	6,300	1/21	0.31J	0/13	ND	0	No
Phenanthrene	230[5]	1/21	0.2J	0/13	ND	0	No
Anthracene	2,300	1/21	0.039J	0/13	ND	0	No
Fluoranthene	310	8/21	0.06J-0.39	4/13	0.12J-0.43	0	No
Pyrene	230	8/21	0.052J-0.47	3/13	0.16J-0.32	0	No
Butylbenzylphthalate	1,600	2/21	0.04J-0.24J	0/13	ND	0	No
Benzo(a)anthracene	0.88	6/21	0.047J-0.4	2/13	0.12J-0.24	0	No
Chrysene	88	7/21	0.056J-0.48	3.13	0.15J-0.27	0	No
Bis(2-ethylhexyl)phthalate	46	5/21	0.038J-6.5	0/13	ND	0	No
Benzo(b)fluoranthene	0.88	9/21	0.048J-0.69	3/13	0.23J-0.5	0	No
Benzo(k)fluoranthene	8.8	6/21	0.043J-0.26J	2/13	0.12J-0.13	0	No
Benzo(a)pyrene	0.088	6/21	0.069J-0.38J	2/13	0.14J-0.18J	2	Yes
Indeno(1,2,3-cd)pyrene	0.88	7/21	0.049J-0.3J	1/13	0.16J	0	No

TABLE 6-2 (Continued)

SURFACE SOIL DATA AND COPC SELECTION SUMMARY
SITE 1
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Contaminant[1]	Region III Criteria[2]	Contaminant Frequency/Range[3]		Background[4]		Comparison to Criteria	COPC Selection
	Residential COC Value (mg/kg)	No. of Positive Detects/ No. of Samples	Range of Positive Detections (mg/kg)	No. of Positive Detects/ No. of Samples	Range of Positive Detections (mg/kg)	Positive Detects Above Residential COC Value	Selected as a COPC?
Dibenzo(a,h)anthracene	0.088	1/21	0.073J	0/13	ND	0	No
Benzo(g,h,i)perylene	230[5]	7/21	0.042J-0.26J	0/13	ND	0	No
Pesticides:							
Dieldrin	0.04	1/21	0.0098J	0/13	ND	0	No
4,4'-DDT	1.9	1/21	0.002J	0/13	ND	0	No
alpha-Chlordane	0.49[6]	1/21	0.002J	0/13	ND	0	No
gamma-Chlordane	0.49[6]	1/21	0.0012	0/13	ND	0	No
PCBs:							
Aroclor-1260	0.083[7]	1/21	0.035J	0/13	ND	0	No
Inorganics:							
Aluminum	7,800	21/21	1,930-11,200	44/44	1,960-19,200	2	Yes
Arsenic (c/n)	0.43/2.3	21/21	0.64L-92.5	44/44	0.466-63.9	21/8	Yes
Barium	550	21/21	6.1-33.6	44/44	4.2J-80.2	0	No
Beryllium	0.15	15/21	0.21-0.55	31/44	0.23J-0.93J	15	Yes
Cadmium	3.9	1/21	0.47K	2/44	1.3K-1.5	0	No
Calcium+	--	21/21	87.6-2,250	44/44	39.4J-7,820	--	No

TABLE 6-2 (Continued)

SURFACE SOIL DATA AND COPC SELECTION SUMMARY
SITE 1
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Contaminant[1]	Region III Criteria[2]	Contaminant Frequency/Range[3]		Background[4]		Comparison to Criteria	COPC Selection
	Residential COC Value (mg/kg)	No. of Positive Detects/ No. of Samples	Range of Positive Detections (mg/kg)	No. of Positive Detects/ No. of Samples	Range of Positive Detections (mg/kg)	Positive Detects Above Residential COC Value	Selected as a COPC?
Chromium	39	21/21	3.4K-12.4	44/44	2.6-18.3	0	No
Cobalt	470	17/21	0.69-4.2	42/44	1J-6.7J	0	No
Copper	310	21/21	1.3-14.6	35/44	1.2J-24.4	0	No
Iron+	2,300	21/21	2,510-11,700	44/44	1,440-19,900	21	Yes
Lead	400[8]	21/21	2.8-62.3K	44/44	6.4-43.1	0	No
Magnesium+	--	21/21	142-888J	44/44	61.5J-1610	--	No
Manganese	190	21/21	16.8J-126	44/44	7.6L-491	0	No
Nickel	160	16/21	2.3K-7.3K	36/44	3.8J-11.9	0	No
Potassium+	--	17/21	198-881	15/44	398J-1,640J	--	No
Selenium	39	1/21	0.28L	23/44	0.26L-0.55L	0	No
Vanadium	55	21/21	5.6-20	44/44	6.1J-34.7J	0	No
Zinc	2,300	21/21	4.4K-43.5	44/44	3.2KJ-48.4	0	No

Notes:

(1) Organic concentrations converted to mg/kg, Inorganic concentrations reported in mg/kg.
(2) COC = USEPA Region III COC screening value (USEPA, 1994a)
(3) L = Estimated value, biased low
J = Analyte was positively identified, value is estimated.
K = Estimated value, biased high.

TABLE 6-2 (Continued)

SURFACE SOIL DATA AND COPC SELECTION SUMMARY
SITE 1
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Notes: (continued)

(4) Baker, 1995.
(5 Value for pyrene used as a surrogate.
(6) Value for chlordane used as a surrogate.
(7) Value for PCBs used as a surrogate.
(8) Action level for residential soils (USEPA, 1994b)
-- = No criteria published
+ = Essential Nutrients

TABLE 6-3A

SURFACE SOIL DATA AND COPC SELECTION SUMMARY
SITE 3
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Contaminant[1]	Region III Criteria[2]	Contaminant Frequency/Range[3]		Background[4]		Comparison to Criteria	COPC Selection
	Residential COC Value (mg/kg)	No. of Positive Detects/ No. of Samples	Range of Positive Detections (mg/kg)	No. of Positive Detects/ No. of Samples	Range of Positive Detections (mg/kg)	Positive Detects Above Residential COC Value	Selected as a COPC?
Semivolatiles:							
Phenanthrene	230[6]	1/15	0.22J	0/13	ND	0	No
Fluoranthene	310	1/15	0.14J	04/13	0.12J - 0.43	0	No
Pyrene	230	1/15	0.24J	03/13	0.16J - 0.32J	0	No
Benzo(a)anthracene	0.88	1/15	0.12J	02/13	0.12J - 0.24J	0	No
Chrysene	88	1/15	0.17J	03/13	0.15J - 0.27J	0	No
Benzo(b)fluoranthene	0.88	1/15	0.22J	03/13	0.23J - 0.50	0	No
Benzo(a)pyrene	0.088	1/15	0.16J	02/13	0.14J - 0.18J	1	Yes
Benzo(g,h,i)perylene	230[6]	1/15	0.087J	0/13	ND	0	No
Pesticides:							
4,4'-DDE	1.9	1/15	0.0085J	0/13	ND	0	No
4,4'-DDD	2.7	1/15	0.0024J	0/13	ND	0	No
4,4'-DDT	1.9	1/15	0.0089J	0/13	ND	0	No
PCBs:							
Aroclor-1260	0.083[9]	2/15	0.025J-0.031J	0/13	ND	0	No

TABLE 6-3A (Continued)

SURFACE SOIL DATA AND COPC SELECTION SUMMARY
SITE 3
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Contaminant[1]	Region III Criteria[2]	Contaminant Frequency/Range[3]		Background[4]		Comparison to Criteria	COPC Selection
	Residential COC Value (mg/kg)	No. of Positive Detects/ No. of Samples	Range of Positive Detections (mg/kg)	No. of Positive Detects/ No. of Samples	Range of Positive Detections (mg/kg)	Positive Detects Above Residential COC Value	Selected as a COPC?
Inorganics:							
Aluminum	7,800	15/15	985-11,800	44/44	1,960-19,200	2	Yes
Antimony	3.1	2/15	4.6L-16.8L	2/42	9.2L - 11L	2	Yes
Arsenic (c/n)	0.43/2.3	15/15	1.2-6.9	44/44	0.466-63.9	15/5	Yes
Barium	550	15/15	3.7-82.6	44/44	4.2J-80.2	0	No
Beryllium	0.15	14/15	0.2-1.5	31/44	0.23J-0.93J	14	Yes
Cadmium	3.9	1/15	0.55L	2/44	1.3K-1.5	0	No
Calcium+	--	13/15	321-2,710	44/44	39.4J-7,820	--	No
Chromium	39	15/15	2.9K-31.6K	44/44	2.6-18.3	0	No
Cobalt	470	15/15	0.55-6	42/44	1J-6.7J	0	No
Copper	310	15/15	0.67-12.9	35/44	1.2J-24.4	0	No
Cyanide	160	1/15	0.89	0/44	ND	0	No
Iron	2,300	15/15	2,460-23,800	44/44	1,440-19,900	15	Yes
Lead	400[10]	15/15	3.1-74.3	44/44	6.4-43.1	0	No
Magnesium+	--	15/15	123-1,050	44/44	61.5J-1,610	--	No
Manganese	190	15/15	6.7-667	44/44	7.6L-491	2	Yes

TABLE 6-3A (Continued)

SURFACE SOIL DATA AND COPC SELECTION SUMMARY
SITE 3
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Contaminant[1]	Region III Criteria[2]	Contaminant Frequency/Range[3]		Background[4]		Comparison to Criteria	COPC Selection
	Residential COC Value (mg/kg)	No. of Positive Detects/ No. of Samples	Range of Positive Detections (mg/kg)	No. of Positive Detects/ No. of Samples	Range of Positive Detections (mg/kg)	Positive Detects Above Residential COC Value	Selected as a COPC?
Mercury	2.3	2/15	0.05-0.11	0/44	ND	0	No
Nickel	160	11/15	2K-8.9	36/44	3.8J-11.9	0	No
Potassium+	--	14/15	193L-1,500L	15/44	398J-1,640J	--	No
Selenium	39	4/15	0.22-0.33L	23/44	0.26L-0.55L	0	No
Sodium+	--	13/15	4.5-29.1	44/44	13.9J - 115J	--	No
Thallium	0.63[11]	1/15	0.23K	0/44	ND	0	No
Vanadium	55	15/15	5.3-37.7	44/44	6.1J-34.7J	0	No
Zinc	2,300	13/15	3.7L-203	44/44	3.2KJ-48.4	0	No

Notes:

(1) Organic concentrations converted to mg/kg, Inorganic concentrations reported in mg/kg.
(2) COC = USEPA Region III COC screening value (USEPA, 1994a)
(3) L = Estimated value, biased low
J = Analyte was positively identified, value is estimated.
K = Estimated value, biased high.
(4) Baker, 1995.
(5) Value for naphthalene used as a surrogate.
(6) Value for pyrene used as a surrogate.
(7) Value for endosulfan used as a surrogate.
(8) Value for endrin used as a surrogate used as a surrogate.
(9) Value for PCBs used as a surrogate.
(10) Action level for residential soils (USEPA, 1994b).
(11) As thallium carbonate/chloride/sulfate.

-- = No criteria published
+ = Essential Nutrients
ND = Not Detected

TABLE 6-3B

SURFACE SOIL DATA AND COPC SELECTION SUMMARY
SITE 3, SVOC AREA OF CONCERN
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Contaminant[1]	Region III Criteria[2]	Contaminant Frequency/Range[3]		Background[4]		Comparison to Criteria	COPC Selection
	Residential COC Value (mg/kg)	No. of Positive Detects/ No. of Samples	Range of Positive Detections (mg/kg)	No. of Positive Detects/ No. of Samples	Range of Positive Detections (mg/kg)	Positive Detects Above Residential COC Value	Selected as a COPC?
Semivolatiles:							
Naphthalene	310	4/6	0.062J-7.3J	0/13	ND	0	No
2-Methylnaphthalene	310[5]	3/6	0.057J-4J	0/13	ND	0	No
Acenaphthylene	230[6]	1/6	0.06J	0/13	ND	0	No
Acenaphthene		4/6	0.26J-18				
Dibenzofuran	31	4/6	0.19J-14	0/13	ND	0	No
Fluorene	310	4/6	0.29J-22	0/13	ND	0	No
Phenanthrene	230[6]	6/6	0.25J-200	0/13	ND	0	No
Anthracene	2,300	6/6	0.065J-47	0/13	ND	0	No
Carbazole	32	6/6	0.043J-37	0/13	ND	1	Yes
Fluoranthene	310	6/6	0.37J-190	4/13	0.12J - 0.43	0	No
Pyrene	230	6/6	0.29J-160	3/13	0.16J - 0.32J	0	No
Benzo(a)anthracene	0.88	6/6	0.16J-92	2/13	0.12J - 0.24J	4	Yes
Chrysene	88	6/6	0.23J-87	3/13	0.15J - 0.27J	0	No
Bis(2-ethylhexyl)phthalate	46	4/6	0.048J-47				
Benzo(b)fluoranthene	0.88	6/6	0.12J-98	3/13	0.23J - 0.50	4	Yes

TABLE 6-3B (Continued)

SURFACE SOIL DATA AND COPC SELECTION SUMMARY
SITE 3, SVOC AREA OF CONCERN
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Contaminant[1]	Region III Criteria[2]	Contaminant Frequency/Range[3]		Background[4]		Comparison to Criteria	COPC Selection
	Residential COC Value (mg/kg)	No. of Positive Detects/ No. of Samples	Range of Positive Detections (mg/kg)	No. of Positive Detects/ No. of Samples	Range of Positive Detections (mg/kg)	Positive Detects Above Residential COC Value	Selected as a COPC?
Benzo(k)fluoranthene	8.8	6/6	0.13J-32J	2/13	0.12J - 0.13J	1	Yes
Benzo(a)pyrene	0.088	6/6	0.17J-77	2/13	0.14J - 0.18J	6	Yes
Indeno(1,2,3-cd)pyrene	0.88	6/6	0.12J-47	1/13	0.16J	4	Yes
Dibenzo(a,h)anthracene	0.088	5/6	0.041J-12	0/13	ND	4	Yes
Benzo(g,h,i)perylene	230[6]	6/6	0.11J-41	0/13	ND	0	No
Pesticides:							
Dieldrin	0.04	1/1	0.0044L	0/13	ND	0	No
Endosulfan Sulfate	47[7]	1/1	0.0053J	0/13	ND	0	No
Methoxychlor	39	1/1	0.062J	0/13	ND	0	No
Endrin Ketone	2.3[8]	1/1	0.021L	0/13	ND	0	No
Inorganics:							
Aluminum	7,800	1/1	10,100	44/44	1,960-19,200	1	Yes
Arsenic (c/n)	0.43/2.3	1/1	9.5	44/44	0.466-63.9	1/1	Yes
Barium	550	1/1	164	44/44	4.2J-80.2	0	No
Beryllium	0.15	1/1	0.98	31/44	0.23J-0.93J	1	Yes
Cadmium	3.9	1/1	0.74K	2/44	1.3K-1.5	0	No

TABLE 6-3B (Continued)

SURFACE SOIL DATA AND COPC SELECTION SUMMARY
SITE 3, SVOC AREA OF CONCERN
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Contaminant[1]	Region III Criteria[2]	Contaminant Frequency/Range[3]		Background[4]		Comparison to Criteria	COPC Selection
	Residential COC Value (mg/kg)	No. of Positive Detects/ No. of Samples	Range of Positive Detections (mg/kg)	No. of Positive Detects/ No. of Samples	Range of Positive Detections (mg/kg)	Positive Detects Above Residential COC Value	Selected as a COPC?
Calcium+	--	1/1	24,000	44/44	39.4J-7,820	--	No
Chromium	39	1/1	16	44/44	2.6-18.3	0	No
Cobalt	470	1/1	1.2	42/44	1J-6.7J	0	No
Copper	310	1/1	10.9	35/44	1.2J-24.4	0	No
Iron	2,300	1/1	8,040	44/44	1,440-19,900	1	Yes
Lead	400[10]	1/1	59.4	44/44	6.4-43.1	0	No
Magnesium+	--	1/1	5,350	44/44	61.5J-1,610	--	No
Manganese	190	1/1	1,580	44/44	7.6L-491	1	Yes
Mercury	2.3	1/1	0.05-0.15	0/44	ND	0	No
Nickel	160	1/1	21.5	36/44	3.8J-11.9	0	No
Potassium+	--	1/1	731K	15/44	398J-1,640J	--	No
Selenium	39	1/1	0.58	23/44	0.26L-0.55L	0	No
Sodium+	--	1/1	252	44/44	13.9J - 115J	--	No
Vanadium	55	1/1	142	44/44	6.1J-34.7J	1	Yes
Zinc	2,300	1/1	180	44/44	3.2KJ-48.4	0	No

TABLE 6-3B (Continued)

SURFACE SOIL DATA AND COPC SELECTION SUMMARY
SITE 3, SVOC AREA OF CONCERN
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Notes:

(1) Organic concentrations converted to mg/kg, Inorganic concentrations reported in mg/kg.
(2) COC = USEPA Region III COC screening value (USEPA, 1994a)
(3) L = Estimated value, biased low
J = Analyte was positively identified, value is estimated.
K = Estimated value, biased high.
(4) Baker, 1995.
(5) Value for naphthalene used as a surrogate.
(6) Value for pyrene used as a surrogate.
(7) Value for endosulfan used as a surrogate.
(8) Value for endrin used as a surrogate used as a surrogate.
(9) Value for PCBs used as a surrogate.
(10) Action level for residential soils (USEPA, 1994b)

-- = No criteria published
+ = Essential Nutrients
ND = Not Detected

TABLE 6-4

SHALLOW SUBSURFACE SOIL DATA AND COPC SELECTION SUMMARY
SITE 1
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Contaminant[1]	Region III Criteria[2]	Contaminant Frequency/Range[3]		Background[4]		Comparison to Criteria	COPC Selection
	Residential COC Value (mg/kg)	No. of Positive Detects/ No. of Samples	Range of Positive Detections (mg/kg)	No. of Positive Detects/ No. of Samples	Range of Positive Detections (mg/kg)	Positive Detects Above Residential COC Value	Selected as a COPC?
Volatiles:							
Acetone	780	1/13	0.05	NA	NA	0	No
Semivolatiles:							
Diethylphthalate	6,300	1/13	0.12J	NA	NA	0	No
Phenanthrene	230[5]	1/13	0.054J	NA	NA	0	No
Di-n-butylphthalate	780	1/13	0.2J	NA	NA	0	No
Fluoranthene	310	3/13	0.083J-0.3J	NA	NA	0	No
Pyrene	230	3/13	0.1J-0.31J	NA	NA	0	No
Benzo(a)anthracene	0.88	3/13	0.046J-0.12J	NA	NA	0	No
Chrysene	88	3/13	0.085J-0.21J	NA	NA	0	No
Bis(2-ethylhexyl)phthalate	46	4/13	0.039J-0.31J	NA	NA	0	No
Benzo(b)fluoranthene	0.88	3/13	0.12J-0.27J	NA	NA	0	No
Benzo(k)fluoranthene	8.8	3/13	0.055J-0.12J	NA	NA	0	No
Benzo(a)pyrene	0.088	3/13	0.059J-0.13J	NA	NA	1	Yes
Indeno(1,2,3-cd)pyrene	0.88	3/13	0.066J-0.14J	NA	NA	0	No
Benzo(g,h,i)perylene	230[5]	3/13	0.06J-0.12	NA	NA	0	No

TABLE 6-4 (Continued)

SHALLOW SUBSURFACE SOIL DATA AND COPC SELECTION SUMMARY
SITE 1
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Contaminant[1]	Region III Criteria[2]	Contaminant Frequency/Range[3]		Background[4]		Comparison to Criteria	COPC Selection
	Residential COC Value (mg/kg)	No. of Positive Detects/ No. of Samples	Range of Positive Detections (mg/kg)	No. of Positive Detects/ No. of Samples	Range of Positive Detections (mg/kg)	Positive Detects Above Residential COC Value	Selected as a COPC?
Pesticides:							
Dieldrin	0.04	1/13	0.004J	NA	NA	0	No
4,4'-DDE	1.9	1/13	0.016J	NA	NA	0	No
4,4'-DDD	2.7	1/13	0.0074J	NA	NA	0	No
4,4'-DDT	1.9	1/13	0.048J	NA	NA	0	No
Alpha-chlordane	0.49[6]	1/13	0.0044J	NA	NA	0	No
Gamma-chlordane	0.49[6]	1/13	0.0037J	NA	NA	0	No
PCBs:							
Aroclor-1260[6]	0.083[7]	2/13	0.025J-0.027J	NA	NA	0	No
Inorganics:							
Aluminum	7,800	13/13	801-7,690	16/16	2,710-28,200	0	No
Arsenic (c/n)	0.43/2.3	13/13	0.32L-126L	16/16	0.23J-42.7	12/13	Yes
Barium	550	13/13	3-53.4J	16/16	10.6J-66.9	0	No
Beryllium	0.15	11/13	0.12-0.38	13/16	0.3J-9.8	8	Yes
Cadmium	3.9	3/13	0.44-1.2	0/16	ND	0	No
Calcium+	--	13/13	75.5-1,350	16/16	28.9J-233,000	--	No

TABLE 6-4 (Continued)

SHALLOW SUBSURFACE SOIL DATA AND COPC SELECTION SUMMARY
SITE 1
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Contaminant[1]	Region III Criteria[2]	Contaminant Frequency/Range[3]		Background[4]		Comparison to Criteria	COPC Selection
	Residential COC Value (mg/kg)	No. of Positive Detects/ No. of Samples	Range of Positive Detections (mg/kg)	No. of Positive Detects/ No. of Samples	Range of Positive Detections (mg/kg)	Positive Detects Above Residential COC Value	Selected as a COPC?
Chromium	39	10/13	2.3-10.2	16/16	5.2L-33.5	0	No
Cobalt	470	10/13	0.73-2.5	12/16	0.97J-156	0	No
Copper	310	13/13	0.4-14.2	16/16	2J-15	0	No
Iron+	2,300	13/13	1,660-9,450	16/16	3,810J-51,100J	9	Yes
Lead	400[8]	13/13	1.1-57.4	16/16	3.6L-25.5L	0	No
Magnesium+	--	13/13	92.2-505	16/16	136J-2,870	--	No
Manganese	190	13/13	3.2K-97.5	16/16	3.5J-2,940	0	No
Nickel	160	8/13	2K-5.1K	13/16	4.2J-145	0	No
Potassium+	--	6/13	146-368L	13/16	392J-2,560	--	No
Vanadium	55	13/13	2.4-14.2	15/16	7.8J-70.3L	0	No
Zinc	2,300	13/13	2K-187	16/16	3.6J-330	0	No

Notes:

(1) Organic concentrations converted to mg/kg, Inorganic concentrations reported in mg/kg.
(2) COC = USEPA Region III COC screening value (USEPA, 1994a).
(3) L = Estimated value, biased low
J = Analyte was positively identified, value is estimated.
K = Estimated value, biased high
(4) Baker, 1995.
(5) Pyrene used as a surrogate.
(6) Chlordane used as a surrogate.
(7) PCBs used as a surrogate.
(8) Action level for residential soils (USEPA, 1994b).

-- = No criteria published
+ = Essential Nutrients
NA = Not Applicable
ND = Not Detected

TABLE 6-5

SHALLOW SUBSURFACE SOIL DATA AND COPC SELECTION SUMMARY
SITE 3
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Contaminant[1]	Region III Criteria[2]	Contaminant Frequency/Range[3]		Background[4]		Comparison to Criteria	COPC Selection
	Residential COC Value (mg/kg)	No. of Positive Detects/ No. of Samples	Range of Positive Detections (mg/kg)	No. of Positive Detects/ No. of Samples	Range of Positive Detections (mg/kg)	Positive Detects Above Residential COC Value	Selected as a COPC?
Volatiles:							
Acetone	780	4/7	0.017J-0.93J	NA	NA	0	No
Methylene chloride	85	1/7	0.015	NA	NA	0	No
1,2-Dichloroethene(total)	70	2/7	0.16-0.2	NA	NA	0	No
2-Butanone	4,700	2/7	0.11-0.16	NA	NA	0	No
Ethylbenzene	780	2/7	0.002J-0.006J	NA	NA	0	No
Semivolatiles:							
4-Methylphenol	39	2/7	0.21J-0.25J	NA	NA	0	No
2-Methylnaphthalene	310[5]	2/7	0.15J-0.38J	NA	NA	0	No
Fluorene	310	1/7	0.067J	NA	NA	0	No
Phenanthrene	230[6]	2/7	0.11J-0.16J	NA	NA	0	No
Bis(2-ethylhexyl)phthalate	46	2/7	0.06J-0.085J	NA	NA	0	No
Pesticides:							
4,4'-DDE	1.9	1/7	0.0046J	NA	NA	0	No
4,4'-DDD	2.7	1/7	0.0042J	NA	NA	0	No

TABLE 6-5 (Continued)

SHALLOW SUBSURFACE SOIL DATA AND COPC SELECTION SUMMARY
SITE 3
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Contaminant[1]	Region III Criteria[2]	Contaminant Frequency/Range[3]		Background[4]		Comparison to Criteria	COPC Selection
	Residential COC Value (mg/kg)	No. of Positive Detects/ No. of Samples	Range of Positive Detections (mg/kg)	No. of Positive Detects/ No. of Samples	Range of Positive Detections (mg/kg)	Positive Detects Above Residential COC Value	Selected as a COPC?
Inorganics:							
Aluminum	7,800	7/7	2,680-15,100	16/16	2,710-28,200	6	Yes
Arsenic (c/n)	0.43/2.3	7/7	0.67L-13.2L	16/16	0.23J-42.7	7/5	Yes
Barium	550	7/7	13.5-54.3	16/16	10.6J-66.9	0	No
Beryllium	0.15	7/7	0.17-3.9	13/16	0.3J-9.8	7	Yes
Calcium+	--	7/7	108-3,420J	16/16	28.9J-233,000	--	No
Chromium	39	7/7	3.5K-65	16/16	5.2L-33.5	2	Yes
Cobalt	470	6/7	2-39.4	12/16	0.97J-156	0	No
Copper	310	7/7	1.3-12	16/16	2J-15	0	No
Iron+	2,300	7/7	3,330-72,700	16/16	3.91-J-51,100J	7	Yes
Lead	400[7]	7/7	1.7L-16.6L	16/16	3.6L-25.5L	0	No
Magnesium+	--	7/7	205-2,700	16/16	136J-2,870	--	No
Manganese	190	7/7	17.8-269	16/16	3.5J-2,940	1	Yes
Mercury	2.3	1/7	0.1	0/16	ND	0	No
Nickel	160	6/7	2.8-31.6	13/16	4.2J-145	0	No
Potassium+	--	6/7	1,540K-3,280	13/16	392J-2,560	--	No

TABLE 6-5 (Continued)

SHALLOW SUBSURFACE SOIL DATA AND COPC SELECTION SUMMARY
SITE 3
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Contaminant[1]	Region III Criteria[2]	Contaminant Frequency/Range[3]		Background[4]		Comparison to Criteria	COPC Selection
	Residential COC Value (mg/kg)	No. of Positive Detects/ No. of Samples	Range of Positive Detections (mg/kg)	No. of Positive Detects/ No. of Samples	Range of Positive Detections (mg/kg)	Positive Detects Above Residential COC Value	Selected as a COPC?
Silver	39	1/7	0.93	5/16	1.1J-2.4J	0	No
Sodium+	--	7/7	5.5-229	15/16	17.2J-2,180	--	No
Vanadium	55	7/7	4.8-84	15/16	7.8J-70.3L	1	Yes
Zinc	2,300	6/7	5.3K-92.4	16/16	3.6J-330	0	No

Notes:

(1) Organic concentrations converted to mg/kg, Inorganic concentrations reported in mg/kg.
(2) COC = USEPA Region III COC screening value (USEPA, 1993a).
(3) L = Estimated value, biased low
J = Analyte was positively identified, value is estimated.
K = Estimated value, biased high
(4) Baker, 1995.
(5) Naphthalene used as a surrogate.
(6) Pyrene used as a surrogate.
(7) Action level for residential soils (USEPA, 1994c).

-- = No criteria published
+ = Essential Nutrients
ND = Not Detected
NA = Not Analyzed

TABLE 6-6

GROUNDWATER DATA AND COPC SELECTION SUMMARY
COLUMBIA AQUIFER (SITE 1)
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Contaminant[1]	Groundwater Criteria[2]			Frequency/Range[3]		Background[4]		Comparison to Criteria			COPC Selection
	Federal MCL (µg/L)	USEPA Region III Tapwater COC Value (µg/L)	Virginia PMCLs (µg/L)	No. of Positive Detects/No. of Samples	Concentration Range (µg/L)	No. of Positive Detects/No. of Samples	Range of Positive Detections (µg/L)	No. of Detects Above MCL	No. of Detects Above COC Value	No. of Detects Above Virginia Criteria	Retained as a COPC?
Volatiles:											
1,2-Dichloroethene(total)	70	5.5	--	1/11	52	0/7	ND	0	1	--	Yes
Trichloroethene	5	1.6	5	2/11	4J-190	0/7	ND	1	2	1	Yes
Semivolatiles:											
Pentachlorophenol	1	0.56	--	1/11	11	0/7	ND	0	1	--	Yes
Nitramines:											
Nitrobenzene	--	0.34	--	3/11	0.7-1.4	0/7	ND	--	3	--	Yes
Inorganics (Total):											
Aluminum	--	3,700	--	8/11	47.8-2,200	7/7	344-3,170	--	0	--	No
Arsenic (as carcinogen)	50	0.0445	50	6/11	1.1L-3.9	1/7	5.2L	0	6	0	Yes
Barium	2,000	260	1,000	11/11	14.2-98.8	7/7	22J-53J	0	0	0	No
Cadmium	5	1.8	10	1/11	8.6	0/7	ND	1	1	0	Yes
Calcium+	--	--	--	11/11	2,150-103,000	7/7	768J-155,000	--	--	--	No
Chromium	100	18	50	1/11	6.4	7/7	2.6L-12.8L	0	0	0	No
Cobalt	--	220	--	5/11	3.3-11.2	5/7	3.1J-5J	--	0	--	No
Copper	1,300	150	1,000	4/11	2.6-8.6	7/7	2J-47J	0	0	0	No
Iron+	--	1,100	--	11/11	229-55,300	7/7	2,050-11,600	--	7	--	Yes
Lead	15	--	50	10/11	0.86-4.7	3/7	1.8L-2.5L	0	--	0	No
Magnesium+	--	--	--	11/11	772-13,500	7/7	489J-3,400J	--	--	--	No
Manganese	--	88	--	9/11	27.4-1,500	7/7	8.8J-105	--	4	--	Yes

TABLE 6-6 (Continued)

GROUNDWATER DATA AND COPC SELECTION SUMMARY
COLUMBIA AQUIFER (SITE 1)
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Contaminant[1]	Groundwater Criteria[2]			Frequency/Range[3]		Background[4]		Comparison to Criteria			COPC Selection
	Federal MCL (µg/L)	USEPA Region III Tapwater COC Value (µg/L)	Virginia PMCLs (µg/L)	No. of Positive Detects/No. of Samples	Concentration Range (µg/L)	No. of Positive Detects/No. of Samples	Range of Positive Detections (µg/L)	No. of Detects Above MCL	No. of Detects Above COC Value	No. of Detects Above Virginia Criteria	Retained as a COPC?
Potassium+	--	--	--	9/11	1,250-3,010	7/7	557-1,740J	--	--	--	No
Selenium	50	18	10	1/11	1.5	0/7	ND	0	0	0	No
Sodium+	--	--	--	11/11	2,070-10,900	7/7	3,67J-7,110	--	--	--	No
Vanadium	--	26	--	7/11	2.7-7.8	7/7	3.4J-16J	--	0	--	No
Zinc	--	1,100	--	7/11	4.8-2,960	7/7	12.7J-30.2J	--	1	--	Yes
Inorganics (Dissolved)											
Aluminum	--	3,700	--	4/11	53.6-966	1/7	20.9J	--	0	--	No
Arsenic	50	0.0445	50	4/11	1.2L-4.4L	0/7	ND	0	4	0	Yes
Barium	2,000	260	1,000	11/11	12.3-101	7/7	13J-37.2J	0	0	0	No
Cadmium	5	1.8	10	1/11	9	0/7	ND	1	1	0	Yes
Calcium+	--	--	--	11/11	2,190-96,600	7/7	611J-129,000	--	--	--	No
Cobalt	--	220	--	7/11	3.6-14.2	2/7	3.2J-4.6J	--	0	--	No
Copper	1,300	150	1,000	4/11	2-27.6	4/7	1.5J-2.3J	0	0	0	No
Iron+	--	1,100	--	7/11	23.9-54,900	7/7	2.6J-17.7J	--	3	--	Yes
Lead	15	--	50	5/11	0.93-3.3	0/7	ND	0	--	0	No
Magnesium+	--	--	--	11/11	777-13,500	7/7	366J-2,520J	--	--	--	No
Manganese	--	88	--	9/11	23.6-1,530	7/7	3.9J-50.4	--	3	--	Yes
Nickel	100	73	--	1/11	12.2	0/7	ND	0	0	--	No
Potassium+	--	--	--	10/11	847-2,710L	7/7	430J-1,270J	--	--	--	No
Sodium+	--	--	--	11/11	2,130-10,400	7/7	3,690J-5,720	--	--	--	No

TABLE 6-6 (Continued)

GROUNDWATER DATA AND COPC SELECTION SUMMARY
COLUMBIA AQUIFER (SITE 1)
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Contaminant[1]	Groundwater Criteria[2]			Frequency/Range[3]		Background[4]		Comparison to Criteria			COPC Selection
	Federal MCL (µg/L)	USEPA Region III Tapwater COC Value (µg/L)	Virginia PMCLs (µg/L)	No. of Positive Detects/No. of Samples	Concentration Range (µg/L)	No. of Positive Detects/No. of Samples	Range of Positive Detections (µg/L)	No. of Detects Above MCL	No. of Detects Above COC Value	No. of Detects Above Virginia Criteria	Retained as a COPC?
Vanadium	--	26	--	1/11	2.4	1/7	12.7J	--	0	--	No
Zinc	--	1,100	--	6/11	4.4L-2,850	7/7	6.5J-15.6J	--	1	--	Yes

Notes:

(1) All concentrations reported in µg/L.
(2) Federal MCL - Federal Safe Drinking Water Act Maximum Contaminant Level (USEPA, 1996; Drinking Water Regulations and Health Advisories)
Virginia Drinking Water Standards - PMCLs - Primary Maximum Contaminant Levels (Bureau of National Affairs - December, 1994)
COC values - USEPA Region III COC screening value (USEPA, 1994a)
(3) J = Analyte was positively identified, value is estimated
L = Value estimated; biased low
K = Value estimated; biased high
(4) Baker, 1995.

ND = Not Detected
NA = Not Applicable
-- = No criteria published
+ = Essential Nutrient

TABLE 6-7

GROUNDWATER DATA AND COPC SELECTION SUMMARY
CORNWALLIS CAVE AQUIFER (SITES 1 AND 3)
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Contaminant[1]	Groundwater Criteria[2]			Frequency/Range[3]		Background[4]		Comparison to Criteria			COPC Selection
	Federal MCL (µg/L)	USEPA Region III Tapwater COC Value (µg/L)	Virginia PMCLs (µg/L)	No. of Positive Detects/No. of Samples	Concentration Range (µg/L)	No. of Positive Detects/No. of Samples	Range of Positive Detections (µg/L)	No. of Detects Above MCL	No. of Detects Above COC Value	No. of Detects Above Virginia Criteria	Retained as a COPC?
Volatiles:											
Vinyl chloride	2	0.019	2	1/17	48	0/8	ND	1	1	1	Yes
Acetone	--	370	--	1/17	18	1/1	15J	--	0	--	No
1,1-Dichloroethene	7	0.044	7	1/17	4J	0/8	ND	0	1	0	Yes
1,2-Dichloroethene(total)	70	5.5	--	4/17	12-570	0/8	ND	2	4	--	Yes
Chloroform	100	0.15	--	1/17	3J	1/8	1	0	1	--	No[5]
Trichloroethene	5	1.6	5	8/17	2J-860	0/8	ND	5	8	5	Yes
Toluene	1,000	75	--	1/17	3J	0/8	ND	0	0	--	No
Semivolatiles:											
Phenol	--	2,200	--	1/17	130	1/8	1J	--	0	--	No
Phenanthrene	--	110	--	3/17	2J-2J	1/8	1J	--	0	--	No
Pyrene	--	110	--	1/17	2J	0/8	ND	--	0	--	No
Di-n-octylphthalate	--	73	--	2/17	3J-4J	0/8	ND	--	0	--	No
Inorganics (Total):											
Aluminum	--	3,700	--	16/17	83.8K-32,300K	8/8	44.9J-14,600L	--	7	--	No
Arsenic (as carcinogen)	50	0.0445	50	12/17	1.6L-24.6	4/8	5J-36.4	0	12	0	Yes
Barium	2000	260	1,000	17/17	11-131	3/8	20.4J-97.5J	0	0	0	No
Beryllium	4	0.016	--	4/17	0.99-2.3	3/8	0.22J-1.5J	0	4	--	No[6]
Cadmium	5	1.8	10	3/17	2.4-3.3	8/8	ND	0	3	0	Yes

TABLE 6-7 (Continued)

GROUNDWATER DATA AND COPC SELECTION SUMMARY
CORNWALLIS CAVE AQUIFER (SITES 1 AND 3)
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Contaminant[1]	Groundwater Criteria[2]			Frequency/Range[3]		Background[4]		Comparison to Criteria			COPC Selection
	Federal MCL (µg/L)	USEPA Region III Tapwater COC Value (µg/L)	Virginia PMCLs (µg/L)	No. of Positive Detects/No. of Samples	Concentration Range (µg/L)	No. of Positive Detects/No. of Samples	Range of Positive Detections (µg/L)	No. of Detects Above MCL	No. of Detects Above COC Value	No. of Detects Above Virginia Criteria	Retained as a COPC?
Calcium+	--	--	--	17/17	31,300-252,000	8/8	48,300-530,000	--	--	--	No
Chromium	100	18	50	10/17	3.7-177	5/8	2.4J-49.6	3	8	3	Yes
Cobalt	--	220	--	9/17	3.3-13.5	3/8	2.5J-22.4J	--	0	--	No
Copper	1,300	150	1,300	12/17	2.7-44.2	1/8	1.3J-14.6J	0	0	0	No
Iron+	--	1,100	--	17/17	212-91,100	1/8	483-48,200	--	13	--	Yes
Lead	15	--	50	12/17	0.95-26.7	2/8	4.8L-12.8	3	--	0	Yes
Magnesium+	--	--	--	17/17	390-14,200	8/8	720J-9770	--	--	--	No
Manganese	--	88	--	16/17	3.6-621	8/8	8.5J-413	--	8	--	Yes
Nickel (soluble salts)	100	73	--	4/17	16.3-58.6	2/8	7.9J-27.6J	0	0	--	No
Potassium+	--	--	--	16/17	1,120-26,300	8/8	1,240J-17000	--	--	--	No
Selenium	50	18	10	5/17	1.4L-2.7	0/8	ND	0	0	0	No
Sodium+	--	--	--	17/17	3,510-38,300	8/8	3,670J-27,200	--	--	--	No
Vanadium	--	26	--	14/17	2.6-225	7/8	2.9J-66.6	--	7	--	Yes
Zinc	--	1,100	--	13/17	3.6-180	8/8	5.9J-99.1J	--	0	--	No
Inorganics (Dissolved)											
Aluminum	--	3,700	--	6/17	23.9K-1,920	2/8	12.9J-212	--	0	--	No
Arsenic	50	0.0445	50	8/17	1-2.7	2/8	3L-5.5L	0	8	0	Yes
Barium	2000	260	1,000	17/17	3.7-35.1	8/8	5.9J-73.4J	0	0	0	No
Cadmium	5	1.8	10	1/17	2.9K	0/8	ND	0	1	0	Yes
Calcium+	--	--	--	1/17	11,100	8/8	25,200-116,000	--	--	--	No

TABLE 6-7 (Continued)

GROUNDWATER DATA AND COPC SELECTION SUMMARY
CORNWALLIS CAVE AQUIFER (SITES 1 AND 3)
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Contaminant[1]	Groundwater Criteria[2]			Frequency/Range[3]		Background[4]		Comparison to Criteria			COPC Selection
	Federal MCL (µg/L)	USEPA Region III Tapwater COC Value (µg/L)	Virginia PMCLs (µg/L)	No. of Positive Detects/No. of Samples	Concentration Range (µg/L)	No. of Positive Detects/No. of Samples	Range of Positive Detections (µg/L)	No. of Detects Above MCL	No. of Detects Above COC Value	No. of Detects Above Virginia Criteria	Retained as a COPC?
Chromium	100	18	50	1/17	7.3	0/8	ND	0	0	0	No
Copper	1300	150	1,000	2/17	3.5-3.9	6/8	1.1J-9J	0	0	0	No
Iron+	--	1,100	--	12/17	12.3-238	6/8	2.8J-347	--	0	--	No
Lead	15	--	50	2/17	0.86-2.4	0/8	ND	0	--	0	No
Magnesium+	--	--	--	15/17	373-4,390	8/8	70.2J-9,810	--	--	--	No
Manganese	--	88	--	13/17	1.8-204	6/8	2.4J-54.4	--	3	--	Yes
Potassium+	--	--	--	14/17	948L-24,300	8/8	1,090J-17,900	--	--	--	No
Sodium+	--	--	--	17/17	3,520-37,300	8/8	3,780J-27,800	--	--	--	No
Vanadium	--	26	--	7/17	2.7-5.5	6/8	1.8J-10.2J	--	0	--	No

Notes:

(1) All concentrations reported in µg/L

(2) Federal MCL - Federal Safe Drinking Water Act Maximum Contaminant Level (USEPA, 1996; Drinking Water Regulations and Health Advisories)
Virginia Drinking Water Standards - PMCLs - Primary Maximum Contaminant Levels (Bureau of National Affairs - December, 1994)
COC values - USEPA Region III COC screening value (USEPA, 1994a)

(3) J = Analyte was positively identified, value is estimated
L = Value estimated; biased low
K = Value estimated; biased high

(4) Baker, 1995.

(5) Compound not selected as COPC due to laboratory contamination.

(6) Constituent not included as a COPC since it was not detected in the dissolved sample. Total inorganic result assumed to be due to the presence of suspended solids.

-- = No criteria published
+ = Essential Nutrient
ND = Not detected

TABLE 6-8

SURFACE WATER DATA AND COPC SELECTION SUMMARY
SITES 1 AND 3
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Contaminant[1]	Federal/State Criteria[2]				Frequency/Range[3]		Background[4]		COPC Selection
	AWQC Freshwater Acute (µg/L)	AWQC Freshwater Chronic (µg/L)	Viginia Freshwater Acute (µg/L)	Virginia Freshwater Chronic (µg/L)	No. of Positive Detects/No. of Samples	Concentration Range (µg/L)	No. of Positive Detects/No. of Samples	Range of Positive Detections (µg/L)	Retained as a COPC?
Inorganics (Total):									
Aluminum	--	--	--	--	4/4	1,110-2,420	17/17	71J-5,600	No
Barium	--	--	--	--	4/4	31-32	17/17	26.6J-49.9J	No
Cadmium	3.9*	1.1*	3.9*	1.1*	4/4	7.8L-9.1L	3/17	5.1K-6.7I	Yes
Calcium+	--	--	--	--	4/4	194,000J-249,000J	17/17	29,200J-198,000J	No
Copper	18*	12*	18*	12*	4/4	7.4K-9.1K	4/17	5.6J-6.7J	No
Iron+	--	1,000	--	--	4/4	1,220J-3,250J	17/17	289J-6,650	No
Lead	83*	32*	83*	32*	2/4	1.8L-2.4L	7/17	1.2L-5.4L	No
Magnesium+	--	--	--	--	4/4	598,000-786,000	17/17	23,000-656,000J	No
Manganese	--	--	--	--	4/4	20.8-54.9J	17/17	33.1-379	No
Potassium+	--	--	--	--	4/4	193,000-249,000	17/17	8,210-220,000J	No
Sodium+	--	--	--	--	4/4	4,680,000-6,040,000	16/17	180,000-5,760,000J	No
Vanadium	--	--	--	--	4/4	9.7-13.4	11/17	5J-14.4J	No
Zinc	120*	110*	120*	110*	4/4	10.4K-20.1K	9/17	7.9J-20.2	No

TABLE 6-8 (Continued)

SURFACE WATER DATA AND COPC SELECTION SUMMARY
SITES 1 AND 3
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Contaminant[1]	Federal/State Criteria[2]				Frequency/Range[3]		Background[4]		COPC Selection
	AWQC Freshwater Acute (µg/L)	AWQC Freshwater Chronic (µg/L)	Viginia Freshwater Acute (µg/L)	Virginia Freshwater Chronic (µg/L)	No. of Positive Detects/No. of Samples	Concentration Range (µg/L)	No. of Positive Detects/No. of Samples	Range of Positive Detections (µg/L)	Retained as a COPC?
Inorganics (dissolved):									
Aluminum	--	--	--	--	3/4	17.2-38.3	5/17	21.4J-45.5J	No
Barium	--	--	--	--	4/4	21.9-26	17/17	17J-48.5J	No
Cadmium	3.9*	1.1*	3.9*	1.1*	3/4	4.8L-8.5L	1/17	5.3	Yes
Calcium+	--	--	--	--	4/4	193,000J-250,000J	17/17	29,400J-207,000J	No
Copper	18*	12*	18*	12*	4/4	5.5K-22.3K	16/17	8.4J-21.6J	Yes
Iron+	--	1,000	--	--	4/4	6.3J-18.2J	16/17	3J-887J	No
Lead	83*	3.2*	83*	3.2*	1/4	2.6L	0/17	ND	No
Magnesium+	--	--	--	--	4/4	597,000-790,000	17/17	25,200-676.000J	No
Manganese	--	--	--	--	3/4	7.6J-29.8J	17/17	2J-290	No
Potassium+	--	--	--	--	4/4	192,000-250,000	17/17	8,810-226,000J	No
Sodium+	--	--	--	--	4/4	4,710,000-6,110,000	16/17	198,000-6,100,000J	No
Vanadium	--	--	--	--	4/4	5.5-8.7	2/17	7.2J-8.6J	No
Zinc	120*	110*	120*	110*	4/4	6.5K-15.7K	2/17	4.5J-4.5J	No

TABLE 6-8 (Continued)

SURFACE WATER DATA AND COPC SELECTION SUMMARY
SITES 1 AND 3
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Notes:

(1) All concentrations reported in µg/L.
(2) Water Quality Criteria (WQC) human health values (recalculated) using IRIS as of 1990 and Virginia Water Standards (Bureau of National Affairs - December 1994).
(3) J = Analyte was positively identified, value is estimated
K = Value is estimated; biased high
L = Value is estimated; biased low
(4) Baker, 1995.

-- = No criteria published
\+ = Essential Nutrient
* = Hardness dependent criteria (100 mg/L $CaCO_3$ used)
ND = Not detected

TABLE 6-9

SEDIMENT DATA AND COPC SELECTION SUMMARY
SITES 1 AND 3
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Contaminant[1]	Sediment Criteria[2]		Contaminant Frequency/Range[3]		Background[4]		Comparison to Criteria		COPC Selection
	SSV ER-M (mg/kg)	SSV ER-L (mg/kg)	No. of Positive Detects/ No. of Samples	Range of Positive Detections (mg/kg)	No. of Positive Detects/ No. of Samples	Range of Positive Detections (mg/kg)	Positive Detects Above ER-M	Positive Detects Above ER-L	Retained as a COPC?
Volatiles:									
Acetone	--	--	4/10	0.066-0.23	16/25	0.014J-0.87J	--	--	No
Carbon disulfide	--	--	3/10	0.01J-0.029	8/25	0.007J-0.12J	--	--	Yes
Toluene	--	--	1/10	0.002J	0/25	ND	--	--	No[5]
Inorganics:									
Aluminum	--	--	10/10	434-21,100	25/25	1,510-40,500	--	--	No
Arsenic (c/n)	70	8.2	8/10	0.63-15.4	25/25	1.4J-13.1	0	4	Yes
Barium	--	--	10/10	1.9J-46.1J	25/25	3.6J-93.2J	--	--	No
Cadmium	9.6	1.2	1/10	1.70	0/25	ND	0	1	Yes
Calcium+	--	--	10/10	341J-129,000J	25/25	7J-4,220	--	--	No
Chromium (VI)	370	81	9/10	1.1-45.8	25/25	3.8-66.1	0	0	No
Cobalt	--	--	7/10	0.46-8.9	24/25	3.8J-15J	--	--	No
Copper	270	34	10/10	0.82-26.7	24/25	3.7J-43.1	0	0	No
Iron+	--	--	10/10	577-39,100	25/25	3,060-46,000	--	--	No
Lead	218	46.7	10/10	0.91-56.8	25/25	3.4-51.6	0	1	Yes

TABLE 6-9 (Continued)

SEDIMENT DATA AND COPC SELECTION SUMMARY
SITES 1 AND 3
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Contaminant[1]	Sediment Criteria[2]		Contaminant Frequency/Range[3]		Background[4]		Comparison to Criteria		COPC Selection
	SSV ER-M (mg/kg)	SSV ER-L (mg/kg)	No. of Positive Detects/ No. of Samples	Range of Positive Detections (mg/kg)	No. of Positive Detects/ No. of Samples	Range of Positive Detections (mg/kg)	Positive Detects Above ER-M	Positive Detects Above ER-L	Retained as a COPC?
Magnesium+	--	--	10/10	60.8-9,050	25/25	292J-9,720J	--	--	No
Manganese	--	--	10/10	3.7-379	25/25	7.4-1,980	--	--	No
Nickel	51.6	21	6/10	11.8-21	23/25	9.3K-55.2	0	0	No
Potassium+	--	--	7/10	141-5,090	23/25	1,200J-6,080	--	--	No
Sodium+	--	--	8/10	318-21,100	25/25	177J-16,700	--	--	No
Vanadium	--	--	10/10	0.79-51.8	25/25	4.8J-67.6	--	--	No
Zinc	410	150	10/10	3.1-135	25/25	4J-202J	0	0	No

Notes:

(1) Organic concentrations converted to mg/kg, Inorganic concentrations reported in mg/kg.
(2) SSV = Sediment Screening Value (Long, et al, 1995).
(3) L = Estimated value, biased low
J = Analyte was positively identified. Reported value may not be accurate or precise.
K = Estimated value, biased high.
(4) Baker, 1995.
(5) Compound not selected as COPC due to laboratory contamination.

-- = No criteria published
+ = Essential Nutrients
ND = Not detected

TABLE 6-10

SUMMARY OF COPCs
SITES 1 AND 3
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

COPCs	Surface Soils Site 1	Surface Soils Site 3	Surface Soils-SVOC Area of Concern Site 3	Shallow Subsurface Soil Site 1	Shallow Subsurface Soil Site 3	Columbia Aquifer (total)	Columbia Aquifer (diss.)	Cornwallis Cave Aquifer (total)	Cornwallis Cave Aquifer (diss.)	Surface Water Sites 1 and 3 (total)	Surface Water Sites 1 and 3 (diss.)	Sediment Sites 1 and 3
Volatiles:												
Carbon Disulfide												X
1,1-Dichloroethene								X	X			
1,2-Dichloroethene						X	X	X	X			
Trichloroethene						X	X	X	X			
Vinyl Chloride								X	X			
Semivolatiles:												
Benzo(a)anthracene			X									X
Benzo(b)fluoranthene			X									
Benzo(k)fluoranthene			X									
Benzo(a)pyrene	X	X	X	X								X
Carbazole			X									
Dibenzo(a,h)anthracene			X									X
Indeno(1,2,3-cd)pyrene			X	X								X
Pentachlorophenol						X	X					
Nitramines:												
Nitrobenzene						X	X					

TABLE 6-10 (Continued)

SUMMARY OF COPCs
SITES 1 AND 3
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

COPCs	Surface Soils Site 1	Surface Soils Site 3	Surface Soils-SVOC Area of Concern Site 3	Shallow Subsurface Soil Site 1	Shallow Subsurface Soil Site 3	Columbia Aquifer (total)	Columbia Aquifer (diss.)	Cornwallis Cave Aquifer (total)	Cornwallis Cave Aquifer (diss.)	Surface Water Sites 1 and 3 (total)	Surface Water Sites 1 and 3 (diss.)	Sediment Sites 1 and 3
Inorganics:												
Aluminum	X	X	X		X							
Antimony		X										
Arsenic	X	X	X	X	X	X	X	X	X			X
Barium												
Beryllium	X	X	X	X	X							
Cadmium						X	X	X	X	X	X	X
Chromium					X							
Copper								X			X	
Iron	X	X	X	X	X	X	X	X		X		
Lead								X				X
Manganese		X	X		X	X	X	X	X			
Vanadium			X		X			X				
Zinc						X	X					

TABLE 6-11

REASONABLE MAXIMUM (RME) AND CENTRAL TENDENCY (CT)[1]
EXPOSURE INPUT PARAMETERS FOR
CURRENT ADULT AND ADOLESCENT ON-STATION TRESPASSERS
SITES 1 AND 3
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Input Parameter	Media	Units	Current Receptor		Comments/References
			Adolescent (7-15 years)	Adult	
ED, Exposure Duration	All media	year	4[2] (NA)	4[2] (NA)	Professional Judgment
EF, Exposure Frequency	All Media	days/year	143[3] (NA)	143[3] (NA)	USEPA, 1989b/ Professional Judgment
ET, Exposure Time	Surface Water	hr/day	2.6 (NA)	2.6 (NA)	USEPA, 1989b
IR, Ingestion Rate	Soil	mg/day	100 (50)	100 (50)	USEPA, 1989b
	Surface Water	L/hr	0.05 (NA)	0.05 (NA)	USEPA, 1989b
SA, Surface Area	All Media	cm^2	3,480[4] (2,973)	5,300[5] (5,000)	USEPA, 1989a and 1992a
FI, Fraction Ingested	Soil/Sediment	unitless	0.5 (NA)	0.5 (NA)	Professional Judgment
ABS, Absorption Factor	Soil/Sediment	unitless	Chemical Specific[6]	Chemical Specific[6]	USEPA, 1995a
AF, Adherence Factor	Soil/Sediment	mg/cm^2	1 (0.2)	1 (0.2)	USEPA, 1992a
BW, Body Weight	All Media	kg	37 (NA)	70 (NA)	USEPA, 1989b
PC, Permeability Constant	Surface Water	cm/hr	Chemical Specific	Chemical Specific	USEPA, 1992a
AT, Averaging Time AT_{nc}, noncarcinogens	All Media	day	1,460[1] (NA)	1,460[1] (NA)	USEPA, 1989b
AT_c, carcinogens	All Media	day	25,550 (NA)	25,550 (NA)	USEPA, 1989b

Notes:

[1] CT exposure input parameters are presented in parentheses.

[2] ED and ATn for on-station trespassers which is the equivalent of a standard four-year tour of duty.

[3] Frequency assumes 3 days/week for the spring and fall months, and 5 days/week for the summer months. Each season was assumed to extend for three months.

[4] Thirty percent (30%) of the median total body surface area for a male adolescent 9-12 years (considered to be representative of an adolescent trespasser), exposing the hands, legs, arms, neck and head.

[5] Skin surface area available for contact assuming an adult wears a short-sleeved shirt, short pants, and shoes.

TABLE 6-11 (Continued)

REASONABLE MAXIMUM (RME) AND CENTRAL TENDENCY (CT)[1]
EXPOSURE INPUT PARAMETERS FOR
CURRENT ADULT AND ADOLESCENT ON-STATION TRESPASSERS
SITES 1 AND 3
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Notes: (continued)

[6] The following absorbance factors will be applied to estimate dermal intake of COPCs:

USEPA Region III Defaults (USEPA, 1995a):	VOCs - 0.05%
	SVOCs/Nitramines - 10%
	PCBs - 6%
	Pesticides - 10%
	Arsenic - 3.2%
	Cadmium - 1%
	Inorganics - 1%

References:

USEPA, 1995a. Assessing Dermal Exposure from Soil.

USEPA, 1992a. Dermal Exposure Assessment: Principles and Applications - Interim Report.

USEPA, 1992b. Interim Region IV Guidance.

USEPA, 1991a. Risk Assessment Guidance for Superfund, Volume I - Human Health Evaluation Manual Supplemental Guidance. "Standard Default Exposure Factors." Interim Final.

USEPA, 1989a. Exposure Factors Handbook.

USEPA, 1989b. Risk Assessment Guidance for Superfund, Volume I - Human Health Evaluation Manual (Part A) Interim Final.

TABLE 6-12

REASONABLE MAXIMUM (RME) AND CENTRAL TENDENCY (CT) EXPOSURE INPUT PARAMETERS FOR FUTURE RESIDENT CHILDREN AND ADULTS SITES 1 AND 3 NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA

Input Parameter	Media	Units	Future Receptor		Comments/References
			Child (1 to 6 years)	Adult	
ED, Exposure Duration	All media	years	6 (NA)	24 (9)	USEPA, 1991a (USEPA, 1993b)
EF, Exposure Frequency	Soil/Groundwater	days/year	350 (234)	350 (234)	USEPA, 1991a (USEPA, 1993b)
	Sediment/ Surface Water	days/year	40[1] (NA)	40[1] (NA)	Professional Judgment
ET, Exposure Time	Surface Water	hrs/day	2.6 (NA)	2.6 (NA)	USEPA, 1989b
	Groundwater	hrs/day	0.2 (NA)	0.2 (NA)	USEPA, 1989a
IR, Ingestion Rate	Groundwater	L/day	1 (NA)	2 (1.4)	USEPA, 1991a (USEPA, 1993b)
	Soil/Sediment	mg/day	200 (100)	100 (50)	USEPA, 1989b (USEPA, 1993b)
	Surface Water	L/day	0.05 (NA)	0.05 (NA)	USEPA, 1989b
SA, Surface Area	Groundwater	cm^2	8,023 (6,978)	20,000 (20,000)	USEPA, 1992a (USEPA, 1992a)
	Soil/Sediment/ Surface Water	cm^2	2,006[1] (1,745)[2]	5,300[1] (5,000)[2]	USEPA, 1989a/192a (USEPA, 1992a)
RR, Respiration Rate	Air	m^3/hr	-- (--)	0.83 (NA)	USEPA, 1991a
FI, Fraction Ingested	Soil/Sediment	unitless	1.0 (NA)	1.0 (NA)	USEPA, 1989b/ Professional Judgment
ABS, Absorbance Factor	Soil/Sediment	unitless	Chemical Specific[3]	Chemical Specific[3]	USEPA, 1995a
AF, Adherence Factor	Soil/Sediment	mg/cm^2	1 (0.2)	1 (0.2)	USEPA, 1992b (USEPA, 1992a)
BW, Body Weight	All Media	kg	15 (NA)	70 (NA)	USEPA, 1989b
PC, Permeability Constant	Groundwater/ Surface Water	cm/hr	Chemical-Specific	Chemical-Specific	USEPA, 1992a

TABLE 6-12 (Continued)

REASONABLE MAXIMUM (RME) AND CENTRAL TENDENCY EXPOSURE INPUT PARAMETERS FOR FUTURE RESIDENT CHILDREN AND ADULTS SITES 1 AND 3 NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA

Input Parameter	Media	Units	Future Receptor		Comments/References
			Child (1 to 6 years)	Adult	
AT, Averaging Time AT_{nc}, noncarcinogens	All Media	day	2,190 (NA)	8,760 (3,285)	USEPA, 1989b/1991a (USEPA, 1993b)
AT_c, carcinogens	All Media	day	25,550 (NA)	25,550 (NA)	USEPA, 1989b

Notes:

(1) Represents 25% of the total body surface area at the 95th percentile value.

(2) Represents 25% of the total body surface area at the 50th percentile value.

(3) The following absorbance factors will be applied to estimate dermal intake of COPCs:

USEPA Region III Defaults (USEPA, 1995a):
- VOCs - 0.05%
- SVOCs/Nitramines - 10%
- PCBs - 6%
- Pesticides - 10%
- Arsenic - 3.2%
- Cadmium - 1%

References:

USEPA, 1995a. Assessing Dermal Exposure from Soil.

USEPA, 1992a. Dermal Exposure Assessment: Principles and Applications – Interim Report.

USEPA, 1992b. Interim Region IV Guidance.

USEPA, 1991a. Risk Assessment Guidance for Superfund, Volume I – Human Health Evaluation Manual Supplemental Guidance. "Standard Default Exposure Factors." Interim Final.

USEPA, 1989a. Exposure Factors Handbook.

USEPA, 1989b. Risk Assessment Guidance for Superfund, Volume I – Human Health Evaluation Manual (Part A) Interim Final.

TABLE 6-13

REASONABLE MAXIMUM (RME) AND CENTRAL TENDENCY (CT)[1]
EXPOSURE INPUT PARAMETERS FOR FUTURE ADULT CONSTRUCTION WORKERS
SITES 1 AND 3
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Input Parameter	Units	Future Receptor	Comments/Reference
		Adult Construction Worker	
ED, Exposure Duration	years	1 (NA)	USEPA, 1991a
EF, Exposure Frequency	days/year	250 (219)	USEPA, 1991a
ET, Exposure Time	hrs/day	8 (NA)	USEPA, 1991a
IR, Ingestion Rate	mg/day	480 (NA)	USEPA, 1991a
SA, Exposed Surface Area	cm^2/day	4,300[2] (3,160)	USEPA, 1992a
RR, Respiration Rate	m^3/hr	0.83 (NA)	USEPA, 1991a
FI, Fraction Ingested	unitless	1.0 (NA)	Professional Judgment
ABS, Dermal Absorption Factor	unitless	Chemical-specific[3]	USEPA, 1995a
AF, Adherence Factor	mg/cm^2	1 (0.2)	USEPA, 1991a and 1992a
BW, Body Weight	kg	70 (NA)	USEPA, 1989b
AT, Averaging Times			
AT_{nc}, noncarcinogens	days	365 (NA)	USEPA, 1989b
AT_c, carcinogens	days	25,550 (NA)	USEPA, 1989b

Notes:

(1) CT exposure input parameters are presented in parentheses.

(2) Skin surface area available for contact for an individual wearing a sleeveless shirt, long pants, and shoes.

TABLE 6-13 (Continued)

REASONABLE MAXIMUM (RME) AND CENTRAL TENDENCY (CT)[1]
EXPOSURE INPUT PARAMETERS FOR FUTURE ADULT CONSTRUCTION WORKERS
SITES 1 AND 3
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Notes: (continued)

[3] The following absorbance factors will be applied to estimate dermal intake of COPCs:

USEPA Region III Defaults (USEPA, 1995a):	VOCs - 0.05%
	SVOCs/Nitramines - 10%
	PCBs - 6%
	Pesticides - 10%
	Arsenic - 3.2%
	Cadmium - 1%
	Inorganics - 1%

NA - Not Applicable

References:

USEPA, 1995a. Assessing Dermal Exposure from Soil.

USEPA, 1992a. Dermal Exposure Assessment: Principles and Applications - Interim Report.

USEPA, 1992b. Interim Region IV Guidance.

USEPA, 1991a. Risk Assessment Guidance for Superfund, Volume I - Human Health Evaluation Manual Supplemental Guidance. "Standard Default Exposure Factors." Interim Final.

USEPA, 1989a. Exposure Factors Handbook.

USEPA, 1989b. Risk Assessment Guidance for Superfund, Volume I - Human Health Evaluation Manual (Part A). Interim Final.

TABLE 6-14

HUMAN HEALTH RISK ASSESSMENT TOXICITY FACTORS
SITES 1 AND 3
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Constituents	Oral CSF $(mg/kg/day)^{-1}$	Inhal. CSFi $(mg/kg/day)^{-1}$	Oral RfD (mg/kg/day)	Inhal. RfDi (mg/kg/day)	Oral Absorption Factors	WOE	Target Organ	Critical Effect
Volatiles:								
1,1-Dichloroethene	6.0E-01 (i)	1.75E-01 (i)	9.0E-03 (i)	--	100%	C	Liver	Lesions
1,2-Dichloroethene (total)	--	--	9.00E-03 (h)	--	100%	D	Blood	Decreased Hematocrit
Trichloroethylene	1.10E-02 (w)	6.00E-03 (e)	6.00E-03 (e)	--	100%	B2	Liver	--
Vinyl Chloride	1.90 (h)	3.00E-01 (h)	--	--	100%	A	Lung	Tumors
Carbon Disulfide	--	--	1.00E-01 (i)	2.00E-01 (i)	100%	--	--	--
Semivolatiles:								
Benzo(a)anthracene	7.3E-01 (e)	6.1E-01 (e)	--	--	50%	B2	--	--
Benzo(a)pyrene	7.3 (i)	6.1 (w)	--	--	50%	B2	--	--
Carbazole	--	--	--	--	--	--	--	--
Dibenzo(a,h)anthracene	7.3 (e)	6.1 (e)	--	--	50%	B2	--	--
Indeno(1,2,3-cd)pyrene	7.3E-01 (e)	6.1E-01 (e)	--	--	50%	B2	--	--
Pentachlorophenol	1.2E-01 (i)	--	3.00E-02 (i)	--	50%	--	--	--

TABLE 6-14 (Continued)

HUMAN HEALTH RISK ASSESSMENT TOXICITY FACTORS
SITES 1 AND 3
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Constituents	Oral CSF $(mg/kg/day)^{-1}$	Inhal. CSFi $(mg/kg/day)^{-1}$	Oral RfD (mg/kg/day)	Inhal. RfDi (mg/kg/day)	Oral Absorption Factors	WOE	Target Organ	Critical Effect
Nitramines:								
Nitrobenzene	--	--	5.00E-04 (i)	5.71E-04 (a)	50%	D	Blood/Adrenal Kidney/Liver	Hematological Effects and Lesions
Inorganics:								
Aluminum	--	--	1.00 (e)	--	20%	NA	NA	NA
Antimony	--	--	4.00E-04 (i)	--	20%	D	Whole Body/Blood	Increased Mortality/ Altered Chemistry
Arsenic	1.5 (i)	15.1 (i)	3.00E-04 (i)	--	95%	A	Skin	Keratosis/ Hyperpigmentation
Beryllium	4.30 (i)	8.40 (i)	5.00E-03 (i)	--	20%	B2	--	None Observed
Cadmium (water)	--	6.30 (i)	5.00E-04 (i)	--	5%	B1	Renal Cortex	Significant Proteinuria
Cadmium (food)	--	6.30 (i)	1.00E-03 (i)	5.71E-05 (e)	2.5%	B1	Renal Cortex	Significant Protenuria
Chromium	--	42.0 (i)	5.00E-03 (i)	--	20%	A	--	None observed
Iron	--	--	3.00E-01	--	20%	NA	Hepatic Parenchyma/ Heart/ Endocrine Glands	Fibrosis/ Cardiac Dysfunction and Failure/ Hypogonadism

TABLE 6-14 (Continued)

HUMAN HEALTH RISK ASSESSMENT TOXICITY FACTORS
SITES 1 AND 3
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Constituents	Oral CSF $(mg/kg/day)^{-1}$	Inhal. CSFi $(mg/kg/day)^{-1}$	Oral RfD (mg/kg/day)	Inhal. RfDi (mg/kg/day)	Oral Absorption Factors	WOE	Target Organ	Critical Effect
Lead	--	--	--	--	--	B2	--	--
Manganese	--	--	2.40E-02 (i)	1.43E-05 (i)	5%	D	CNS/Lung	Adverse Effects
Vanadium	--	--	7.00E-03 (h)	--	20%	D	--	--
Zinc	--	--	3.00E-01 (i)	--	25%	D	Blood	Decreased Blood Enzyme

Notes:

(1) Naphthalene used as a surrogate.
(2) HEAST FY-1994 Supplement No. 1, July 1994.
i = Integrated Risk Information System (IRIS), 1996.
e = EPA-NCEA (as cited from January - June, 1996, USEPA, Region III RBC Tables).
h = Health Effects Assessment Summary Tables (HEAST), May, 1995.
a = HEAST Alternative Method, 1994.
w = Withdrawn from IRIS or HEAST.
NA = Not Available
-- = Information not published

TABLE 6-15

TOTAL SITE LIFETIME INCREMENTAL CANCER RISK (ICR) AND HAZARD INDEX (HI) VALUES FOR POTENTIAL CURRENT RECEPTORS[1]
SITES 1 AND 3
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Receptors[2]	Site 1		Site 3	
	Total ICR	Total HI	Total ICR	Total HI
On-Station Adult Trespasser	3.6×10^{-06}	0.24	2.2×10^{-06} (4.2×10^{-06})	0.3 (0.1)
On-Station Adult Trespasser (with SVOC AOC)	NA	NA	1.7×10^{-04} (1.5×10^{-05})	0.8 (0.2)
On-Station Adolescent Trespasser	4.9×10^{-06}	0.32	3.1×10^{-06} (6.0×10^{-07})	0.4 (0.1)
On-Station Adolescent Trespasser (with SVOC AOC)	NA	NA	2.2×10^{-04} (1.8×10^{-05})	1.0 (0.2)

Notes:

Shaded values in table represent exceedences of USEPA acceptable risk criteria (i.e., target ICR range of 1×10^{-06} to 1×10^{-04} and target HI value of 1.0). Values in parentheses represent central tendency risks.

(1) On-station adolescent and adult trespassers could potentially be exposed to COPCs by accidental ingestion and dermal contact of surface soils, surface water and sediments.

TABLE 6-16

TOTAL SITE LIFETIME INCREMENTAL CANCER RISK (ICR) AND HAZARD INDEX (HI) VALUES FOR POTENTIAL FUTURE RECEPTORS [1]
SITES 1 AND 3
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Receptors	Site 1		Site 3	
	Total ICR	Total HI	Total ICR	Total HI
Resident (Columbia aquifer)[2]	1.4×10^{-04} (4.0×10^{-05})	11 (2.9)	NA	NA
Resident (Columbia - 1GW20)[3]	1.2×10^{-04} (1.1×10^{-05})	5.5 (0.8)	NA	NA
Resident (Cornwallis Cave aquifer)[4]	5.4×10^{-04} (1.2×10^{-04})	6.7 (1.9)	4.8×10^{-04} (7.7×10^{-05})	7.0 (2.2)
Resident (Cornwallis Cave aquifer with SVOC AOC)	NA	NA	4.6×10^{-03} (1.5×10^{-03})	13 (5.6)
Resident (Cornwallis Cave - 1GW12B)[5]	1.9×10^{-04} (2.2×10^{-05})	8.2 (1.3)	NA	NA
Resident (Cornwallis Cave -3GW19)[6]	NA	NA	1.6×10^{-03} (1.1×10^{-04})	23 (1.7)
Resident (Cornwallis Cave -3GW19 with SVOC AOC)	NA	NA	5.7×10^{-03} (1.5×10^{-03})	28 (5.1)
Construction Worker	4.5×10^{-06}	0.8	2.3×10^{-06} (1.2×10^{-06})	1.6 (0.8)

Notes:

[1] Shaded values in table represent exceedences of USEPA acceptable risk criteria (i.e., target ICR range of 1×10^{-06} to 1×10^{-04} and target HI value of 1.0). Values in parentheses represent central tendency risks. Values in table represent sums of adult and child risks (i.e., total lifetime risks) for future residents.

[2] Adult and child (ages 1-6 years) residents evaluated for potential exposures to surface soil, groundwater (95%UCL or maximum over all Columbia aquifer monitoring well data), surface water and sediment.

[3] Adult and child (ages 1-6 years) residents evaluated for potential exposures to surface soil, groundwater (concentrations from well location 1GW20), surface water and sediment.

[4] Adult and child (ages 1-6 years) residents evaluated for potential exposures to surface soil, groundwater (95%UCL or maximum over all Cornwallis Cave aquifer monitoring well data), surface water and sediment.

TABLE 6-16 (Continued)

TOTAL SITE LIFETIME INCREMENTAL CANCER RISK (ICR) AND HAZARD INDEX (HI) VALUES FOR POTENTIAL FUTURE RECEPTORS [1]
SITES 1 AND 3
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Notes (Continued):

[5] Adult and child (ages 1-6 years) residents evaluated for potential exposures to surface soil, groundwater (concentrations from well location 1GW12B), surface water and sediment.

[6] Adult and child (ages 1-6 years) residents evaluated for potential exposures to surface soil, groundwater (concentrations from well location 3GW19), surface water and sediment.

NA - Not applicable.

TABLE 6-17

**INCREMENTAL LIFETIME CANCER RISK (ICR) AND HAZARD INDEX (HI)[1]
FOR CURRENT ON-STATION ADULT AND ADOLESCENT TRESPASSERS
RME AND CENTRAL TENDENCY VALUES
SITE 3
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA**

Pathway	Receptors			
	Adults		Adolescents (7-15 yrs.)	
	ICR	HI	ICR	HI
Surface Soil				
Ingestion	1.5×10^{-07} (6.1×10^{-08})	0.02 (0.01)	2.8×10^{-07} (1.2×10^{-07})	0.04 (0.02)
Dermal Contact	9.3×10^{-07} (1.7×10^{-07})	0.2 (0.02)	1.2×10^{-06} (1.9×10^{-07})	0.2 (0.02)
Subtotal	1.1×10^{-06} (2.3×10^{-07})	0.2 (0.03)	1.5×10^{-06} (3.1×10^{-07})	0.2 (0.04)
Surface Soil - SVOC AOC				
Ingestion	7.8×10^{-06} (1.7×10^{-06})	0.04 (0.02)	1.5×10^{-05} (3.3×10^{-06})	0.1 (0.04)
Dermal Contact	1.6×10^{-04} (1.3×10^{-05})	0.5 (0.1)	2.0×10^{-04} (1.5×10^{-05})	0.6 (0.1)
Subtotal	1.7×10^{-04} (1.5×10^{-05})	0.5 (0.1)	2.2×10^{-04} (1.8×10^{-05})	0.7 (0.1)
Surface Water[4]				
Ingestion	NA (NA)	0.02 (0.02)	NA (NA)	0.04 (0.03)
Dermal Contact	NA (NA)	0.04 (0.03)	NA (NA)	0.04 (0.03)
Subtotal	NA (NA)	0.06 (0.05)	NA (NA)	0.08 (0.06)

TABLE 6-17 (Continued)

INCREMENTAL LIFETIME CANCER RISK (ICR) AND HAZARD INDEX (HI)
FOR CURRENT ON-STATION ADULT AND ADOLESCENT TRESPASSERS
RME AND CENTRAL TENDENCY VALUES
SITE 3
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Pathway	Receptors			
	Adults		Adolescents (7-15 yrs.)	
	ICR	HI	ICR	HI
Sediment				
Ingestion	2.5×10^{-07} (8.3×10^{-08})	0.01 (<0.01)	4.7×10^{-07} (1.6×10^{-07})	0.02 (0.01)
Dermal Contact	8.8×10^{-07} (1.1×10^{-07})	0.05 (0.01)	1.1×10^{-06} (1.3×10^{-07})	0.06 (0.01)
Subtotal	1.1×10^{-06} (1.9×10^{-07})	0.06 (0.01)	1.6×10^{-06} (2.9×10^{-07})	0.08 (0.02)
TOTAL	2.2×10^{-06} (4.2×10^{-07})	0.3 (0.1)	3.1×10^{-06} (6.0×10^{-07})	0.4 (0.1)
TOTAL (with SVOC AOC)	1.7×10^{-04} (1.5×10^{-05})	0.8 (0.2)	2.2×10^{-04} (1.8×10^{-05})	1.0 (0.2)

Notes:

(1) Shaded values in table represent exceedences of USEPA acceptable risk criteria (i.e., target ICR range of 1×10^{-06} to 1×10^{-04} and target HI value of 1.0). Values in parentheses represent central tendency risks.
(2) Risk value derived using organic and dissolved inorganic concentrations.
(3) VOCs in shower water.
(4) Risk value derived using organic and total inorganic concentrations.

TABLE 6-18

INCREMENTAL LIFETIME CANCER RISK (ICR) AND HAZARD INDEX (HI)[1]
FOR FUTURE ADULT AND CHILD ON-SITE RESIDENTS
RME AND CENTRAL TENDENCY VALUES
SITE 1
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Pathway	Receptors			
	Adults		Children (1-6 yrs.)	
	ICR	HI	ICR	HI
Surface Soil				
Ingestion	1.3×10^{-05} (9.0×10^{-07})	0.1 (0.02)	3.0×10^{-05} (5.6×10^{-06})	1.1 (0.2)
Dermal Contact	2.8×10^{-05} (8.7×10^{-07})	0.2 (0.02)	1.3×10^{-05} (9.4×10^{-07})	0.4 (0.03)
Subtotal	4.1×10^{-05} (1.8×10^{-06})	0.3 (0.04)	4.3×10^{-05} (6.5×10^{-06})	1.5 (0.2)
Columbia Aquifer[2]				
Ingestion	3.2×10^{-05} (5.4×10^{-06})	2.7 (0.6)	1.9×10^{-05} (1.2×10^{-05})	6.2 (1.9)
Dermal Contact	2.4×10^{-06} (6.2×10^{-06})	0.06 (0.03)	1.1×10^{-06} (6.7×10^{-06})	0.1 (0.05)
Inhalation[3]	2.8×10^{-07} (3.2×10^{-08})	<0.01 (<0.01)	NA (NA)	NA (NA)
Subtotal	3.5×10^{-05} (1.2×10^{-05})	2.8 (0.6)	2.0×10^{-05} (1.9×10^{-05})	6.3 (2.0)
Columbia Aquifer - 1GW20[2]				
Ingestion	2.0×10^{-05} (4.4×10^{-07})	1.0 (0.1)	1.1×10^{-05} (9.7×10^{-07})	2.4 (0.3)
Dermal Contact	6.3×10^{-07} (2.0×10^{-08})	0.03 (<0.01)	2.9×10^{-07} (2.2×10^{-08})	0.1 (0.01)
Inhalation[3]	9.9×10^{-07} (3.2×10^{-08})	<0.01 (<0.01)	NA (NA)	NA (NA)
Subtotal	2.2×10^{-05} (4.9×10^{-07})	1.0 (0.1)	1.2×10^{-05} (1.0×10^{-06})	2.5 (0.3)

TABLE 6-18 (Continued)

**INCREMENTAL LIFETIME CANCER RISK (ICR) AND HAZARD INDEX (HI)
FOR FUTURE ADULT AND CHILD ON-SITE RESIDENTS
RME AND CENTRAL TENDENCY VALUES
SITE 1
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA**

Pathway	Receptors			
	Adults		Children (1-6 yrs.)	
	ICR	HI	ICR	HI
Cornwallis Cave Aquifer[2]				
Ingestion	2.7×10^{-04} (3.1×10^{-05})	1.4 (0.34)	1.6×10^{-04} (7.2×10^{-05})	3.2 (1.1)
Dermal Contact	3.8×10^{-06} (5.8×10^{-07})	0.04 (0.01)	1.8×10^{-06} (6.4×10^{-07})	0.1 (0.02)
Inhalation[3]	6.2×10^{-06} (1.0×10^{-06})	<0.01 (<0.01)	NA (NA)	NA (NA)
Subtotal	2.8×10^{-04} (3.3×10^{-05})	1.4 (0.4)	1.6×10^{-04} (7.3×10^{-05})	3.3 (1.1)
Cornwallis Cave Aquifer - 1GW12B[2]				
Ingestion	5.8×10^{-05} (3.9×10^{-06})	1.8 (0.2)	3.4×10^{-05} (9.0×10^{-06})	4.2 (0.7)
Dermal Contact	1.2×10^{-06} (7.4×10^{-08})	0.06 (0.01)	5.8×10^{-07} (8.1×10^{-08})	0.1 (0.01)
Inhalation	1.9×10^{-06} (1.1×10^{-07})	<0.01 (<0.01)	NA (NA)	NA (NA)
Subtotal	6.1×10^{-05} (4.1×10^{-06})	1.9 (0.2)	3.5×10^{-05} (9.0×10^{-06})	4.3 (0.7)
Surface Water[4]				
Ingestion	NA (NA)	0.01 (0.01)	NA (NA)	0.03 (0.02)
Dermal Contact	NA (NA)	0.01 (0.01)	NA (NA)	0.02 (0.01)
Subtotal	NA (NA)	0.02 (0.02)	NA (NA)	0.05 (0.03)

TABLE 6-18 (Continued)

**INCREMENTAL LIFETIME CANCER RISK (ICR) AND HAZARD INDEX (HI)
FOR FUTURE ADULT AND CHILD ON-SITE RESIDENTS
RME AND CENTRAL TENDENCY VALUES
SITE 1
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA**

Pathway	Receptors			
	Adults		Children (1-6 yrs.)	
	ICR	HI	ICR	HI
Sediment				
Ingestion	8.3×10^{-07} (1.0×10^{-07})	0.01 (<0.01)	1.9×10^{-06} (6.5×10^{-07})	0.1 (0.02)
Dermal Contact	1.5×10^{-06} (7.0×10^{-08})	0.01 (<0.01)	6.5×10^{-07} (7.6×10^{-08})	0.02 (<0.01)
Subtotal	2.3×10^{-06} (1.7×10^{-07})	0.02 (<0.01)	2.6×10^{-06} (7.3×10^{-07})	0.12 (0.02)
TOTAL (Columbia Aquifer)	7.8×10^{-05} (1.4×10^{-05})	3.1 (0.6)	6.6×10^{-05} (2.6×10^{-05})	8.0 (2.3)
TOTAL (Columbia Aquifer - 1GW20)	6.5×10^{-05} (2.4×10^{-06})	1.3 (0.2)	5.8×10^{-05} (8.2×10^{-06})	4.2 (0.6)
TOTAL (Cornwallis Cave Aquifer)	3.3×10^{-04} (3.5×10^{-05})	1.7 (0.5)	2.1×10^{-04} (8.0×10^{-05})	5.0 (1.4)
TOTAL (Cornwallis Cave Aquifer - 1GW12B)	1.1×10^{-04} (6.0×10^{-05})	2.2 (0.3)	8.1×10^{-05} (1.6×10^{-05})	6.0 (0.97)

Notes:

(1) Shaded values in table represent exceedences of USEPA acceptable risk criteria (i.e., target ICR range of 1×10^{-06} to 1×10^{-04} and target HI value of 1.0). Values in parentheses represent central tendency risks.
(2) Risk value derived using organic and dissolved inorganic concentrations.
(3) VOCs in shower water.
(4) Risk value derived using organic and total inorganic concentrations.

TABLE 6-19

INCREMENTAL LIFETIME CANCER RISK (ICR) AND HAZARD INDEX (HI)[1]
FOR FUTURE ADULT AND CHILD ON-SITE RESIDENTS
RME AND CENTRAL TENDENCY VALUES
SITE 3
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Pathway	Receptors			
	Adults		Children (1-6 yrs.)	
	ICR	HI	ICR	HI
Surface Soil				
Ingestion	4.4×10^{-06} (4.5×10^{-07})	0.1 (0.03)	1.0×10^{-05} (2.8×10^{-06})	0.99 (0.1)
Dermal Contact	1.4×10^{-05} (2.6×10^{-06})	0.4 (0.14)	6.1×10^{-06} (3.4×10^{-06})	0.6 (0.2)
Subtotal	1.8×10^{-05} (3.1×10^{-06})	0.5 (0.2)	1.6×10^{-05} (6.2×10^{-06})	1.6 (0.3)
Surface Soil - SVOC AOC				
Ingestion	2.3×10^{-04} (1.0×10^{-04})	0.2 (0.2)	5.4×10^{-04} (8.0×10^{-05})	2.0 (0.7)
Dermal Contact	2.4×10^{-03} (1.0×10^{-03})	1.2 (1.2)	1.0×10^{-03} (2.6×10^{-04})	2.2 (1.3)
Subtotal	2.6×10^{-03} (1.1×10^{-03})	1.4 (1.4)	1.5×10^{-03} (3.4×10^{-04})	4.2 (2.0)
Cornwallis Cave Aquifer[2]				
Ingestion	2.7×10^{-04} (3.2×10^{-05})	1.4 (0.34)	1.6×10^{-04} (7.2×10^{-05})	3.2 (1.1)
Dermal Contact	3.8×10^{-06} (5.8×10^{-07})	0.04 (0.01)	1.8×10^{-06} (6.4×10^{-07})	0.1 (0.02)
Inhalation[3]	6.2×10^{-06} (1.0×10^{-06})	<0.01 (<0.01)	NA (NA)	NA (NA)
Subtotal	2.8×10^{-04} (3.4×10^{-05})	1.4 (0.4)	1.6×10^{-04} (7.3×10^{-05})	3.3 (1.2)

TABLE 6-19 (Continued)

INCREMENTAL LIFETIME CANCER RISK (ICR) AND HAZARD INDEX (HI)
FOR FUTURE ADULT AND CHILD ON-SITE RESIDENTS
RME AND CENTRAL TENDENCY VALUES
SITE 3
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Pathway	Receptors			
	Adults		Children (1-6 yrs.)	
	ICR	HI	ICR	HI
Cornwallis Cave Aquifer - 3GW19[2]				
Ingestion	9.7×10^{-04} (3.0×10^{-05})	5.9 (0.2)	5.6×10^{-04} (6.7×10^{-05})	14 (0.9)
Dermal Contact	1.5×10^{-05} (5.8×10^{-07})	0.2 (0.01)	7.2×10^{-06} (6.3×10^{-07})	0.3 (0.02)
Inhalation[3]	2.4×10^{-05} (1.0×10^{-06})	<0.01 (<0.01)	<0.01 (<0.01)	NA (NA)
Subtotal	1.0×10^{-03} (3.2×10^{-05})	6.1 (0.2)	5.7×10^{-04} (6.7×10^{-05})	14 (0.9)
Surface Water[4]				
Ingestion	NA (NA)	<0.01 (0.004)	NA (NA)	0.03 (0.02)
Dermal Contact	NA (NA)	0.01 (0.01)	NA (NA)	0.05 (0.01)
Subtotal	NA (NA)	0.01 (0.01)	NA (NA)	0.05 (0.03)
Sediment				
Ingestion	8.3×10^{-07} (1.0×10^{-07})	0.01 (0.002)	1.9×10^{-06} (6.5×10^{-07})	0.1 (0.02)
Dermal Contact	1.5×10^{-06} (7.0×10^{-08})	0.01 (0.002)	6.5×10^{-07} (7.6×10^{-08})	0.02 (<0.01)
Subtotal	2.3×10^{-06} (1.7×10^{-07})	0.02 (0.004)	2.6×10^{-06} (7.3×10^{-07})	0.12 (0.02)

TABLE 6-19 (Continued)

**INCREMENTAL LIFETIME CANCER RISK (ICR) AND HAZARD INDEX (HI)
FOR FUTURE ADULT AND CHILD ON-SITE RESIDENTS
RME AND CENTRAL TENDENCY VALUES
SITE 3
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA**

Pathway	Receptors			
	Adults		Children (1-6 yrs.)	
	ICR	HI	ICR	HI
TOTAL (Cornwallis Cave Aquifer)	3.0×10^{-04} (3.7×10^{-05})	1.9 (0.6)	1.8×10^{-04} (4.0×10^{-05})	5.1 (1.6)
TOTAL (Cornwallis Cave Aquifer with SVOC AOC)	2.9×10^{-03} (1.1×10^{-03})	3.3 (2.0)	1.7×10^{-03} (3.8×10^{-04})	9.3 (3.6)
TOTAL (Cornwallis Cave Aquifer - 3GW19)	1.0×10^{-03} (3.5×10^{-05})	6.6 (0.4)	5.9×10^{-04} (7.4×10^{-05})	16 (1.3)
TOTAL (Cornwallis Cave Aquifer - 3GW19 with SVOC AOC)	3.6×10^{-03} (1.1×10^{-03})	8 (1.8)	2.1×10^{-03} (4.1×10^{-04})	20 (3.3)

Notes:

(1) Shaded values in table represent exceedences of USEPA acceptable risk criteria (i.e., target ICR range of 1×10^{-06} to 1×10^{-04} and target HI value of 1.0). Values in parentheses represent central tendency risks.
(2) Risk value derived using organic and dissolved inorganic concentrations.
(3) VOCs in shower water.
(4) Risk value derived using organic and total inorganic concentrations.

TABLE 6-20

INCREMENTAL LIFETIME CANCER RISK (ICR) AND HAZARD INDEX (HI)[1]
FOR FUTURE ADULT CONSTRUCTION WORKERS
RME AND CENTRAL TENDENCY VALUES
SITE 3
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Pathway	Adult Construction Worker	
	ICR	HI
Subsurface Soil		
Ingestion	1.7×10^{-06} (9.1×10^{-07})	1.1 (0.6)
Dermal Contact	6.1×10^{-07} (2.4×10^{-07})	0.5 (0.2)
Inhalation	4.7×10^{-09} (3.0×10^{-09})	<0.01 (<0.01)
TOTAL	2.3×10^{-06} (1.2×10^{-06})	1.6 (0.8)

Notes:

(1) Shaded values in table represent exceedences of USEPA acceptable risk criteria (i.e., target ICR range of 1×10^{-06} to 1×10^{-04} and target HI value of 1.0). Values in parentheses represent central tendency risks.

TABLE 6-21

SUMMARY OF UNCERTAINTIES IN THE RESULTS OF THE HUMAN HEALTH RISK ASSESSMENT SITES 1 AND 3 NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA

	Potential Magnitude for Over-Estimation of Risks	Potential Magnitude for Under-Estimation of Risks	Potential Magnitude for Over or Under-Estimation of Risks
Environmental Sampling and Analysis Sufficient samples may not have been taken to characterize the media being evaluated.			Low
Systematic or random errors in the chemical analysis may yield erroneous data.			Low
Selection of COPCs The use of USEPA Region III COC screening values in selecting COPCs in soil and groundwater.			Low
The use of USEPA Region III tapwater COC screening values and the AWQC in selecting COPCs in surface water for human health evaluation.	Moderate		
The use of SSVs and USEPA Region III residential COPC screening values in selecting COPCs in sediment for human health evaluation.	Moderate		
Exposure Assessment The standard assumptions regarding body weight, exposure period, life expectancy, population characteristics, and lifestyle may not be representative of the actual exposure situations.			Moderate
The use of the 95% UCL of the arithmetic mean in the estimation of the soil, surface water and sediment exposure point concentrations.	Low		
Using the maximum concentration in point-source groundwater monitoring wells in the estimation of the exposure point concentration.	Moderate		
Using one-half of the CRQL as a surrogate concentration in the derivation of the 95% UCL.			Moderate
Assessing future residential property use when the likelihood of residential development is low.	High		
The amount of media intake is assumed to be constant and representative of any actual exposure.			Low
Toxicological Assessment Toxicological indices derived from high dose animal studies, extrapolated to low dose human exposure.	Moderate		

TABLE 6-21 (Continued)

SUMMARY OF UNCERTAINTIES IN THE RESULTS OF THE HUMAN HEALTH RISK ASSESSMENT SITES 1 AND 3 NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA

	Potential Magnitude for Over-Estimation of Risks	Potential Magnitude for Under-Estimation of Risks	Potential Magnitude for Over or Under-Estimation of Risks
Lack of promulgated toxicological indices for the inhalation pathway.		Low	
Adjusting toxicity values for a difference in toxicity between an administered dose and an absorbed dose.	Moderate		
Risk Characterization Assumption of additivity in the quantitation of cancer risks without consideration of synergism, antagonism, promotion and initiation.			Moderate
Assumption of additivity in the estimation of systemic health effects without consideration of synergism, antagonism, etc.			Moderate
Additivity of risks by individual exposure pathways (dermal, ingestion and inhalation)			Low
Compounds not quantitatively evaluated.		Low	

Notes:

Low - Assumptions categorized as "low" may effect risk estimates by less than one order of magnitude.

Moderate - Assumptions categorized as "moderate" may effect estimates of risk by between one and two orders of magnitude.

High - Assumptions categorized as "high" may effect estimates of risk by more than two orders of magnitude.

Source: Risk Assessment Guidance for Superfund, Volume 1, Part A: Human Health Evaluation Manual. USEPA, 1989b.

FIGURES

FIGURE

CONCEPTUAL SITE MODEL
SITE 1
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

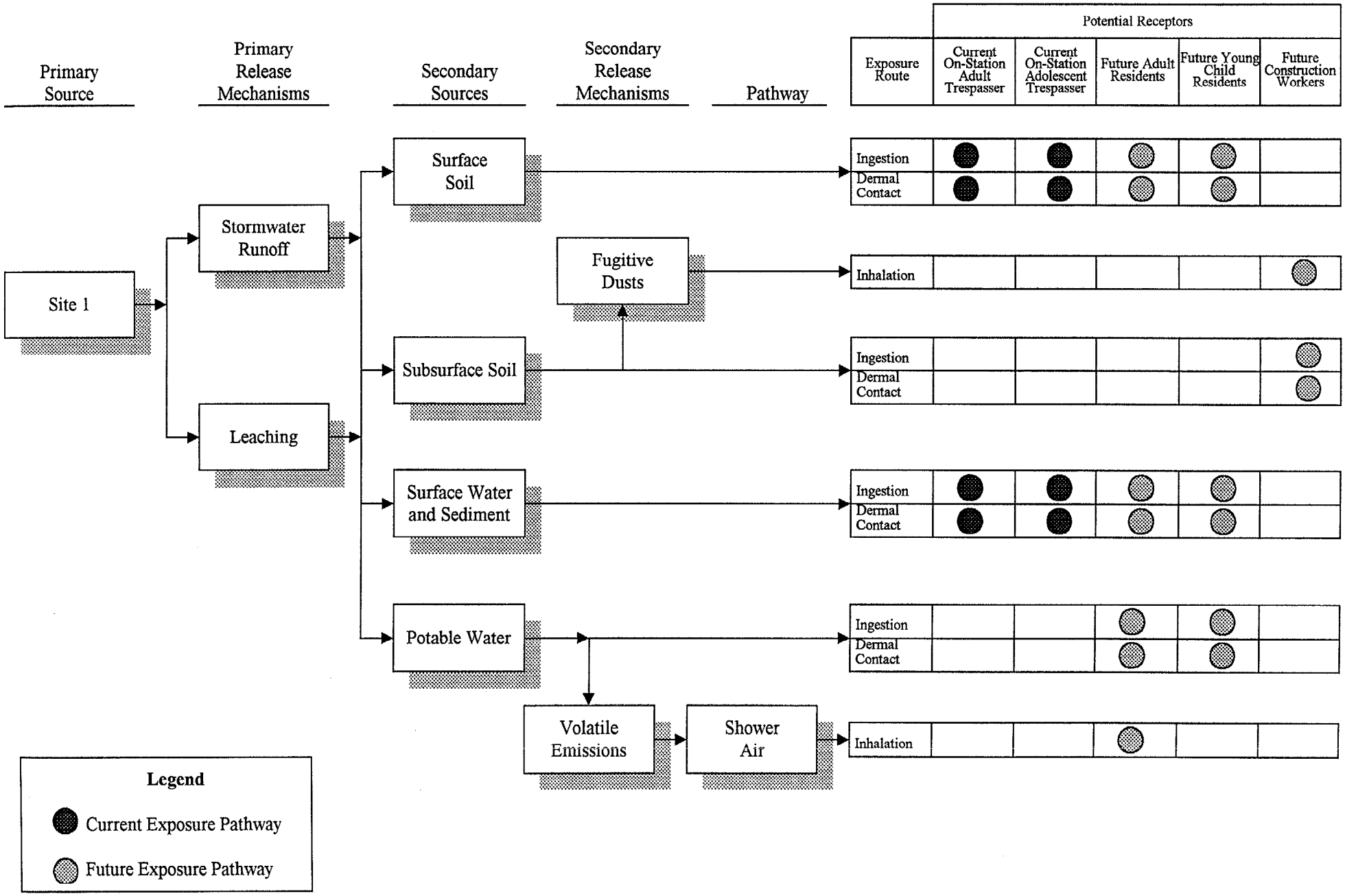
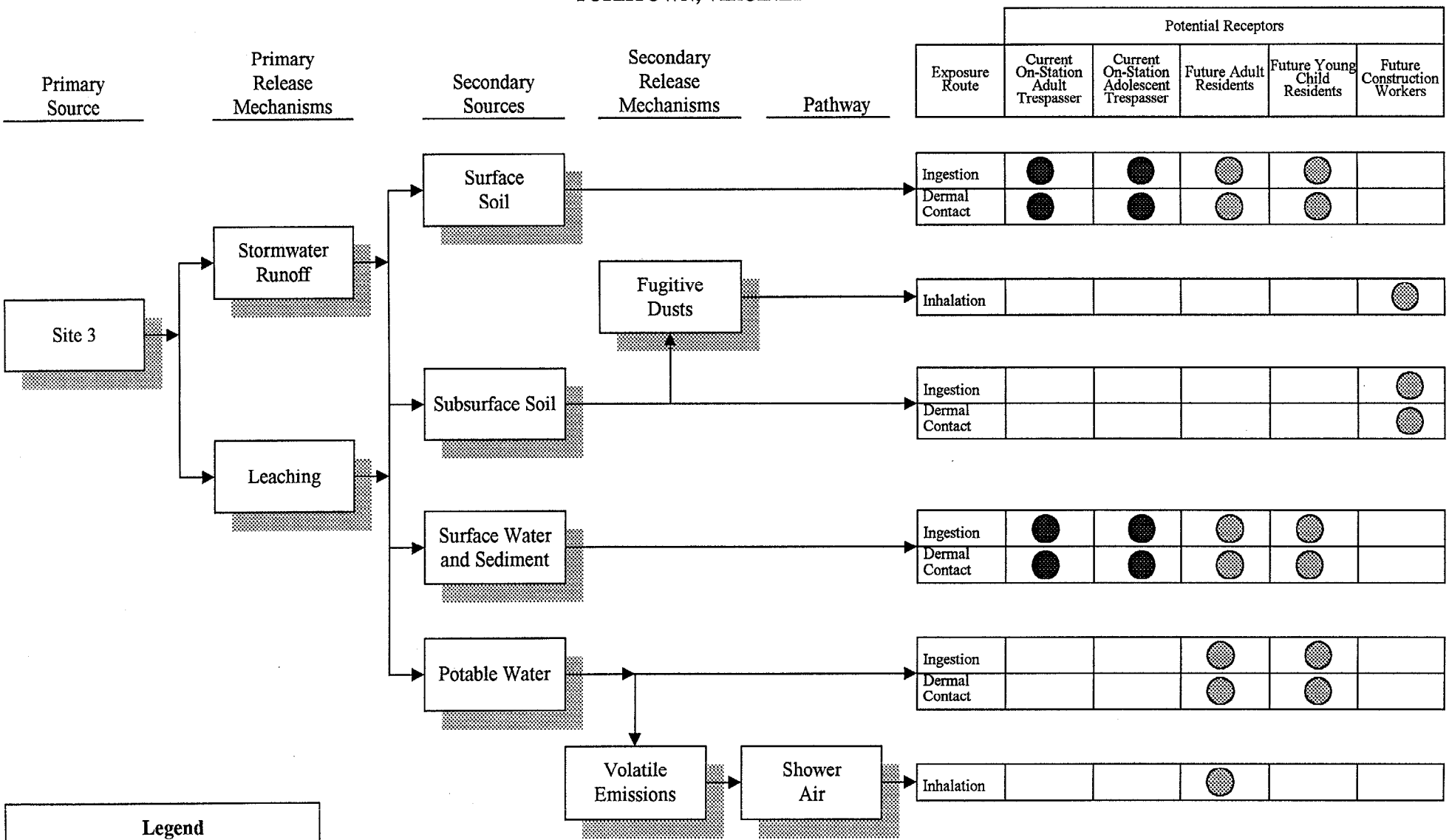


FIGURE .

CONCEPTUAL SITE MODEL
SITE 3
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA



7.0 ECOLOGICAL RISK ASSESSMENT

This section presents a Phase Two ecological risk assessment (RA) for Sites 1 and 3 at the Naval Weapons Station (WPNSTA) Yorktown, Yorktown, Virginia. The objective of this ecological RA is to evaluate whether past site operations at Sites 1 and 3 have or potentially may adversely affect the terrestrial and aquatic communities at or adjacent to the sites. The risk assessment methodologies used in this evaluation were consistent with those outlined in the Ecological Risk Assessment Guidance for Superfund (USEPA, 1994) and the Proposed Guidelines for Ecological Risk Assessment (USEPA, 1996).

During the Remedial Investigation (RI) of Site 3, a soil area of concern (AOC) contaminated with polynuclear aromatic hydrocarbons (PAHs) was identified. This area of concern will be referred to as the Soil AOC in this ecological RA. The ecological investigation of Sites 1 and 3 is divided into three terrestrial assessments: Site 1, Site 3 Proper, and the Soil AOC at Site 3. One aquatic assessment was conducted on surface water and sediment samples collected from Indian Field Creek, which is located adjacent to Sites 1 and 3. Benthic macroinvertebrate samples were also collected from Indian Field Creek. Due to the low salinities and tidal nature of this creek, the benthic population is not expected to be indicative of site contamination. Therefore, benthic macroinvertebrates were not evaluated in this ecological RA. The samples were archived for future analysis, if necessary.

The data used in this ecological RA were collected during the Round Two RI. Surface soil samples were collected in January of 1996 and surface water and sediment samples were collected in September of 1995. Confirmatory surface soil samples were collected in the soil AOC in July of 1996. The confirmatory samples were used in this ecological RA; however, these additional samples were only analyzed for target compound list (TCL) semivolatile organic compounds (SVOCs).

The following subsections present a description of Sites 1 and 3. Information used to evaluate sensitive environments was obtained from the Natural Heritage Inventory conducted at WPNSTA Yorktown by the Commonwealth of Virginia (Buhlman and Ludwig, 1992). In addition, a qualitative habitat evaluation was conducted at Sites 1 and 3 in 1994 to identify potential terrestrial and aquatic receptors (Baker, 1995a). Specific details on the local ecology at Sites 1 and 3 are presented in Section 1.0.

Site 1 - Dudley Road Landfill

Site 1 is a 6-acre area just north of the headwaters of Indian Field Creek. The landfill was in use from approximately 1965 to 1979 for general disposal. This landfill was reportedly used for disposal of plastic lens grinding waste until 1983. Originally, the site was used for sand mining. Two unfilled burrow pits are found at this site. One is located within the eastern portion of the site quadrant and is vegetated with loblolly pines. The other burrow pit is located in the southwest portion of the site and accumulates surface water runoff. The water within this burrow pit fluctuates throughout the year from a few inches to 2-feet deep. Seasonal ponding also occurs in the southeastern section of Site 1. Wastes reportedly disposed within the depression created by sand mining include asbestos insulation from steam piping, oil, grease, paint, solvents, nitramine-contaminated carbon, household appliances, scrap metal banding, construction rubble, plastic lens grinding waste, tree limbs, lumber, packaging wastes, electrical wires, and waste oil. This landfill is covered by approximately two feet of soil and the abandoned sand reclamation area is covered by eight feet of soil.

No freshwater drainage channels are associated with Site 1. However, the southeastern portion of the site borders Indian Field Creek. Indian Field Creek is a tidally-influenced tributary to the York River.

Three different terrestrial habitats are present in the vicinity of Site 1. These include an open field with the pond, a scrub shrub/mixed forest present along the edges of the open area, and an upland forest between the old landfill and the marsh. The open field is dominated by a mixture of grasses and herbaceous perennial and annual plants. Several species of trees and shrubs are scattered across the open field. Trees dominate the scrub shrub/mixed forest along the edges of the open field. Several areas of loblolly pine are present in this area. In addition, seedling and sapling trees, grasses, and herbaceous field plants are present in the understory of the scrub shrub/mixed forest edges.

Upland forest is present as a narrow band between the former landfill and the marsh along Indian Field Creek. Flocks of birds were observed on the site, particularly on the fruits of the shrubs. Two neotropical migrant birds were observed at this site, the Tennessee warbler (*Vermivora peregrina*)

and the alder flycatcher (*Empidonax alnorum*). Evidence of box turtles, white-tailed deer, eastern cottontail rabbits, squirrels, raccoons, and groundhogs also was noted at Site 1.

Site 3 - Group 16 Magazines Landfill

Site 3 is a 2-acre area located behind the Group 16 Magazines, just south of Site 1 (separated from Site 1 by a ravine), along the headwaters of Indian Field Creek. The history of this landfill is not related to operations at the magazines. The landfill operated from approximately 1940 to 1970. The site was originally used for sand mining. Wastes disposed within the depression (an unfilled burrow pit) created by sand mining include solvents, sludge from boiler cleaning operations, grease trap wastes, Imhoff tank skimmings containing oil and grease, and animal carcasses. Currently, most of the site, which is overgrown with trees, is covered by approximately two feet of soil with some scattered surface debris.

Similar to Site 1, there are no freshwater drainage channels associated with Site 3. However, Site 3 is situated adjacent to Indian Field Creek and upstream of Site 1.

Three general terrestrial habitats are present at Site 3. The habitats include a mixed deciduous forest over most of the disposal area, a small open area dominated by herbaceous plants, and a mature upland forest along the edges of the disposal area and between the disposal area and the creek. The mixed forest in the disturbed area is dominated by trees that are relatively young. The understory of the mixed forest is well vegetated and includes seedling trees, vines, shrubs, ferns, grasses, and herbs. The small open area contains grasses, perennial and annual herbaceous plants, and seedling trees.

The mature upland forest is dominated by trees, but has a very sparse understory. Signs or sightings of birds, reptiles, white-tailed deer, and squirrels were noted at Site 3.

7.1 Problem Formulation

This ecological RA was designed to evaluate potential threats to ecological receptors from exposure to site contaminants. The problem formulation process included the identification of potential ecological contaminants of concern (ECOCs). The ECOCs were selected based on a screening of

the maximum detected values in the surface soil, surface water, and sediment against screening levels. The screening levels used in this ecological RA are discussed in Appendix 7A of this report. Exceedance of a screening level was the criterion used to identify potential ECOCs at the sites. In addition, laboratory contaminants [e.g., acetone, carbon disulfide, toluene, and bis(2-ethylhexyl)phthalate] and constituents with low toxicity characteristics (e.g., calcium, magnesium, potassium, and sodium) were eliminated as potential ECOCs.

Once the ECOCs were identified, the maximum detected concentrations of the ECOCs were compared with accepted benchmark values [preferably No Adverse Effects Levels (NOAELs)]. This information was used to identify potential risks to ecological receptors and their appropriate measurement endpoints.

7.1.1 Selection of the Ecological Contaminants of Concern

The first step of this ecological RA was to select the ECOCs at Sites 1 and 3. The following sections present the selected ECOCs in each media. It is noted that groundwater concentrations detected in the Cornwallis Cave Aquifer at Sites 1 and 3 were screened against tidal freshwater screening levels. The groundwater was only screened for a qualitative discussion. Groundwater data was not used to determine risks to ecological receptors because aquatic receptors are not directly exposed to groundwater. A summary of the ECOCs in each ecological media sampled at Sites 1 and 3 is presented in Table 7-1.

7.1.1.1 Site 1

Twenty-one surface soil samples were collected at Site 1 and analyzed for TCL organics, Target Analyte List (TAL) inorganics, and nitramine compounds. Eleven SVOCs, 2,4-dinitrotoluene, aluminum, beryllium, chromium, iron, lead, nickel, vanadium, and zinc exceeded surface soil screening levels (SSSLs) and were retained as ECOCs. Table 7-2 summarizes the frequency and range of detections in surface soil and the selection criteria.

7.1.1.2 Site 3 Proper

Fifteen surface soil samples were collected from Site 3 Proper during the Round Two RI and analyzed for TCL organics, TAL inorganics, and nitramine compounds. Seven SVOCs, aluminum, antimony, beryllium, chromium, cyanide, iron, lead, manganese, mercury, nickel, thallium, vanadium, and zinc exceeded SSSLs and were retained as ECOCs. Table 7-3 summarizes the frequency and range of detections in surface soil and the selection criteria.

7.1.1.3 Site 3 - Soil Area of Concern

Six surface soil samples (six samples were analyzed for TCL VOCs and SVOCs, six samples were analyzed for nitramine compounds and one sample was analyzed for TCL Pesticides/PCBs and TAL inorganics) were collected during the Round Two RI and the confirmatory sampling investigation in the Soil AOC. Eighteen SVOCs, aluminum, beryllium, chromium, iron, lead, manganese, mercury, nickel, vanadium, and zinc exceeded SSSLs and were retained as ECOCs. Table 7-4 summarizes the frequency and range of detections in surface soil and the selection criteria.

7.1.1.4 Sites 1 and 3

An aquatic ecological RA was conducted on the surface water and sediment collected from Indian Field Creek at Sites 1 and 3. In addition, the groundwater collected from the Cornwallis Cave aquifer that potentially may discharge into Indian Field Creek was screened against surface water screening levels (SWSLs). The receptor models calculated for the aquatic assessments included the input of surface water and sediment concentrations detected in Indian Field Creek. The following subsections present ECOCs selected in the various aquatic media at Sites 1 and 3.

Groundwater

The Cornwallis Cave aquifer groundwater data were compared with tidal freshwater SWSLs. The groundwater data were not used to determine risks to ecological receptors.

Seventeen groundwater samples were analyzed for TCL organics, TAL inorganics, and nitramine compounds. The groundwater exceeded tidal freshwater SWSLs for di-n-octylphthalate, arsenic,

chromium, copper, lead, manganese, nickel, and zinc. Table 7-5 summarizes the frequency and range of detections in groundwater and the selection criteria. No SWSLs were available for aluminum, cobalt or iron. They were retained as ECOCs for qualitative evaluations.

Surface Water

Four tidal freshwater surface water samples were analyzed for TCL organics, TAL inorganics, and nitramine compounds. The surface water samples were collected from Indian Field Creek. Copper, manganese, and zinc exceeded SWSLs and were retained as ECOCs at Sites 1 and 3. Table 7-6 presents the ECOCs selected and the rational for exclusion of the constituents that were not retained. No SWSLs were available for aluminum or iron. They were retained as ECOCs for qualitative evaluations.

Sediment

Ten sediment samples were analyzed for TCL organics, TAL inorganics, and nitramine compounds during the Round Two RI. The sediment was collected from Indian Field Creek and drainage ways to the creek. Sediment samples were collected from 0 to 4 inches and 4 to 8 inches below the sediment surface. Arsenic, cadmium, iron, lead, manganese, nickel, and vanadium exceeded sediment screening levels (SSLs). Table 7-7 presents the ECOCs selected in the sediment and the rational for exclusion of those constituents that were not retained. No SSLs were available for aluminum and cobalt. These inorganics were retained as ECOCs for qualitative evaluations.

7.1.2 Exposure Characterization

To determine the effects of ECOCs on biota, the mechanisms of toxicity and the systems that they affect need to be identified. Ecological toxicological profiles for each ECOC identified in the surface soil, surface water, and sediment are provided in Appendix 7A.

7.1.3 Hazard Characterization

The objective of the exposure assessment is to identify the pathways and media through which receptors may be exposed to site contaminants. Potential exposure pathways are dependant on

habitats and receptors present on the sites, the extent and magnitude of contaminant, and environmental fate and transport of the ECOCs.

In the terrestrial habitat at Site 1, SVOCs, 2,4-dinitrotoluene, and inorganics were retained as ECOCs in the surface soil. In the terrestrial habitat at Site 3, SVOCs and inorganics were retained as ECOCs in the surface soil. In the aquatic habitat at Sites 1 and 3, inorganics were retained as ECOCs in the surface water and sediment.

The mean and maximum concentrations were used in this ecological RA to determine potential risks to ecological receptors. Arithmetic mean and maximum concentrations of ECOCs are presented in Appendix 7B of this report.

Accumulation of the ECOCs present in vegetation and prey species via ingestion could cause toxicity in higher trophic level organisms. In addition to exposure via consumption of contaminated vegetation, ecological receptors may be exposed through direct ingestion of water, soil, or sediment. The exposure pathways evaluated in this ecological RA were the ingestion of water, soil, sediment, vegetation, and/or the ingestion of small mammals. In addition, the risk to benthic macroinvertebrates was determined by comparing existing sediment benchmark values with the maximum concentration of contaminants in the sediment.

7.1.4 Assessment Endpoints

Assessment endpoints are explicit expressions of environmental values that need to be protected (USEPA, 1992a). Thirteen assessment endpoints were selected to evaluate the risk of contaminants to the habitat at Sites 1 and 3:

1) Protection of benthic invertebrate communities from toxic effects of contaminants in sediment to maintain species diversity, biomass, and nutrient cycling (trophic structure); to provide a food source for higher level consumers; and to insure those contaminant levels in benthic invertebrate tissues are low enough to minimize the risk of bioaccumulation and/or other negative toxic effects in higher trophic levels.

2) Protection of fish communities from toxic effects of contaminants in sediment and surface water to maintain species diversity; to insure that ingestion of contaminants in fish and invertebrates does not have a negative impact on growth, survival, and reproduction; and to insure that contaminant levels accumulated in fish tissues are low enough to minimize risk of accumulation and negative effects in higher trophic levels.

3) Protection of birds that feed on aquatic life to insure that ingestion of contaminants in surface water, sediment and food organisms do not have negative impact on growth, survival, and reproduction.

4) Protection of amphibians from contaminants in surface water, sediment, and vegetation to maintain species diversity to provide a food source for higher level consumers; and to insure that contaminant levels in amphibians and reptiles are low enough to minimize risk of bioaccumulation and/or other negative effects in higher trophic levels.

5) Protection of soil invertebrate communities to maintain species diversity and nutrient cycling (trophic structure); to provide a food source for higher level consumers; and to insure those contaminant levels in insect tissues are low enough to minimize the risk of bioaccumulation and/or other negative effects in higher trophic levels.

6) Protection of worm-eating birds to insure that ingestion of contaminants in earthworms and soil does not have a negative impact on growth, survival, and reproduction.

7) Protection of carnivorous birds to insure that ingestion of contaminants in prey and soil does not have a negative impact on growth, survival, and reproduction.

8) Protection of omnivorous birds to insure that ingestion of contaminants in food items and soils does not have a negative impact on growth, survival, and reproduction.

9) Protection of carnivorous mammals to insure that ingestion of contaminants in prey and soils does not have a negative impact on growth, survival, and reproduction.

10) Protection of insectivorous mammals to insure that ingestion of contaminants in prey and soil does not have a negative impact on growth, survival, and reproduction.

11) Protection of herbivorous mammals to insure that ingestion of contaminants in forage and soil does not have a negative impact on growth, survival, and reproduction; to provide a food source for higher level consumers; and to insure those contaminant levels in herbivore tissues are low enough to minimize risk of bioaccumulation and/or other negative effects in higher trophic levels.

12) Protection of omnivorous mammals to insure that contaminants in food items and soils do not have a negative impact on growth, survival, and reproduction, to provide food source for higher level consumers, and to insure that contaminant levels in omnivore tissues are low enough to minimize risk of bioaccumulation.

13) Protection of vegetation to insure that soil contamination does not have a negative impact on species diversity and plant vitality.

7.1.5 Hypothesis Formulation

Testable hypotheses were developed to determine the potential threat to the endpoints presented. The hypotheses generated for Sites 1 and 3 are presented below.

- Are the levels of site contaminants in sediment sufficient to cause adverse alterations to the structure and/or function of the benthic community, at either the population or community level?

- Are levels of site contaminants in surface water and sediment sufficient to cause adverse effects on the fish community at this site?

- Are levels of site contaminants in the surface water and sediment sufficient to cause adverse effects on the long-term health and reproductive capacity of amphibian species using the site?

- Are the levels of site contaminants in soil sufficient to cause adverse alterations to the structure and/or function of the soil invertebrate community?

- Are levels of contaminants in the surface water, sediment, and soil sufficient to cause adverse effects on the long-term health and reproductive capacity of avian species that utilize the site?

- Are levels of site contaminants in the surface water, sediment, and soil sufficient to cause adverse effects on the long-term health and reproductive capacity of mammal species using the site?

- Are the levels of site contaminants in soil sufficient to cause adverse alterations to the species diversity and vitality of the vegetative community at the site?

7.1.6 Measurement Endpoints

Measurement endpoints are measurable ecological characteristics that are related to the assessment endpoint (USEPA, 1992a). This section presents the measurement endpoints selected for each assessment endpoint at Sites 1 and 3.

Measurement endpoints for assessment endpoint:

- Ecological health of the benthic macroinvertebrate community, specifically in terms of the structure and function.

To evaluate the structure and function of the benthic macroinvertebrate community, each ECOC identified in the sediment collected from Indian Field Creek was assessed through a comparison with literature toxicity benchmark values.

Measurement endpoints for assessment endpoint:

- Ecological health of the fish communities that inhabit waterbodies potentially impacted by Sites 1 and 3.

The fish communities inhabiting the waterbody adjacent to the sites can be influenced by contaminants in two ways: short-term toxicity to larvae and juveniles using this site; and long-term reproductive effects on organisms exposed to contaminants as larvae or juveniles. The selected measurement endpoint receptor species is the largemouth bass. Levels of contaminants measured in the surface water and sediment were compared with levels documented to cause adverse impacts to fish.

Measurement endpoints for assessment endpoint:

- Long-term ecological health and reproductive capacity of amphibian species that inhabit the site.

Food chain accumulation models were selected to evaluate risk to amphibian species which utilize the site as a feeding area. The bullfrog was selected as the measurement endpoint receptor. Appropriate forage species were identified for the above receptor and the dietary exposure of the receptor to contaminants was quantified.

Measurement endpoints for assessment endpoint:

- Ecological health of the soil invertebrate community, specifically in terms of the structure and function.

To evaluate the species diversity and structure of the soil invertebrate community, each ECOC identified in the surface soil was assessed through a literature review and the literature levels compared with those found at the site.

Measurement endpoints for assessment endpoint:

- Long-term ecological health and reproductive capacity of avian species that utilize the site.

Food chain accumulation studies were selected to evaluate risk to avian species which utilize the site as a feeding area. Selected measurement endpoint receptor species include the American woodcock

as a worm-eating species, great blue heron as a fish-eating species, red-tailed hawk as a carnivorous species, the marsh wren as an insect-eating species, and the American robin as omnivorous species. Appropriate forage species were identified for the above receptors, and the dietary exposure of the receptors to contaminants was quantified and compared to existing toxicity data for these, or other closely related species.

Measurement endpoints for assessment endpoint:

- Long-term ecological health and reproductive capacity of mammal species that utilize the site.

Food chain accumulation studies were selected to evaluate risk to mammalian species which utilize the sites and adjacent areas. Selected measurement endpoint receptor species include the short-tailed shrew as an insectivorous species, red fox as a carnivorous species, deer mouse as an omnivorous species and the meadow vole as a herbivorous species. Appropriate forage species were identified for the above receptors and the dietary exposure of the receptors to contaminants was qualified.

Measurement endpoints for assessment endpoint:

- Ecological health of the vegetation at the site, specifically in terms of species diversity and plant vitality.

To evaluate the potential impact to the plant community at the site, each ECOC identified in the surface soil was assessed through a literature review and the literature levels compared with those found at the site.

Receptor species were selected to represent several trophic levels. Organisms that are likely to be exposed to contaminants because of specific behaviors, patterns of habitat use, or feeding habits were selected for evaluation in this ecological RA. The availability of appropriate exposure information on which risk calculations could be based was also an important consideration. The terrestrial receptor species selected for this assessment included: American woodcock (*Scolopax minor*), red-tailed hawk (*Buteo jamaicensis*), American robin (*Turdus migratorius*), marsh wren (*Cistothorus palustris*), red fox (*Vulpes vulpes*), short-tailed shrew (*Blarina brevicauda*), meadow

vole (*Microtus pennsylvanicus*), and deer mouse (*Peromyscus maniculatus*). The aquatic species selected included the largemouth bass (*Micropterus salmoides*), the great blue heron (*Ardea herodias*), and the bullfrog (*Rana catesbeiana*). These species were selected because of their presence on-site, their importance in the food chain, or because the habitat on or near the sites can support the species.

7.1.7 Exposure Pathway Conceptual Model

The conceptual model identifies critical exposure pathways to the measurement endpoints. At Site 1, PAHs, butylbenzylphthalate, dibenzofuran, and inorganics in surface soil may pose risks to the flora and fauna community. At Site 3 butylbenzylphthalate, dibenzofuran, PAHs, and inorganics may pose risks to flora and fauna community at the site. In addition, potential for risk exists to higher trophic level receptors exposed to contaminants in the surface soil at Sites 1 and 3 via incidental ingestion of the soil or ingestion of the flora and fauna species. Inorganics in the surface water and sediment may pose risks to benthic macroinvertebrates and fish inhabiting Indian Field Creek. Higher trophic level receptors may be exposed to contaminants in the surface water and sediment via ingestion of surface water, sediment, and aquatic receptors within the waterway. The following pathways were evaluated in this ecological RA:

I. Benthic Macroinvertebrates
   - a) Comparison of sediment concentrations to benchmark criteria

II. Largemouth Bass
   - a) Ingestion of aquatic invertebrates
   - b) Ingestion of fish
   - c) Ingestion of surface water
   - d) Incidental ingestion of sediment

III. Great Blue Heron
   - a) Ingestion of fish
   - b) Ingestion of surface water
   - c) Incidental ingestion of sediment

IV. Bullfrog

a) Ingestion of sediment invertebrates

b) Ingestion of surface water

c) Incidental ingestion of sediment

V. Surface Soil Flora and Fauna

a) Comparison of surface soil concentrations to benchmark criteria

VI. American Woodcock

a) Ingestion of earthworms

b) Ingestion of surface water

c) Incidental ingestion of soil

VII. Red-Tailed Hawk

a) Ingestion of small mammals

b) Ingestion of surface water

c) Incidental ingestion of soil

VIII. American Robin

a) Ingestion of terrestrial invertebrates/earthworms/vegetation

b) Ingestion of surface water

c) Incidental ingestion of soil

IX. Marsh Wren

a) Ingestion of terrestrial invertebrates

b) Ingestion of surface water

c) Incidental ingestion of soil

X. Red Fox

a) Ingestion of small mammals

b) Ingestion of surface water

c) Incidental ingestion of soil

XI. Short-Tailed Shrew

a) Ingestion of terrestrial invertebrates

b) Ingestion of surface water

c) Incidental ingestion of soil

XII. Meadow Vole

a) Ingestion of vegetation

b) Ingestion of surface water

c) Incidental ingestion of soil

XIII. Deer Mouse

a) Ingestion of vegetation

b) Ingestion of terrestrial invertebrates

c) Ingestion of surface water

d) Incidental ingestion of soil

7.2 Assumptions

This ecological RA evaluates exposure to contaminants through food, water, and incidental ingestion of sediment or surface soil. The following assumptions were made to conduct this ecological RA:

- The maximum ECOC concentrations detected in the surface soil, surface water, and sediment were assumed to be present site-wide. Maximum concentrations and arithmetic mean concentrations of the ECOCs were used in the receptor modeling calculations.

- A biota to soil/water/sediment accumulation factor (BSAF) of 1 was assumed for the vegetation, invertebrates, fish, and small mammals.

- The ECOCs were assumed to be 100 percent bioavailable.

- Dietary consumption information was obtained from the literature for the receptor species. However, simplifications of diets were performed for the receptors. It is

noted that no data were located on fish consumption of surface water and sediment; therefore, these pathways were not assessed in the largemouth bass receptor model. In addition, no data were located on frog consumption of water; therefore, this pathway was not assessed in the bullfrog model.

- A literature search was conducted to determine toxicity benchmark values for the ECOCs when ingested by the receptor species. If no toxicity values could be found for the receptor species, values reported for a closely related species were used. When values for chronic toxicity were not available, median lethal dose (LD_{50})values were used. A factor of 100 was used to convert reported LD_{50}s to NOAELs. A factor of 10 was used to convert reported Lowest Observed Adverse Effect Levels (LOAELs) to NOAELs. If several toxicity values were reported for a receptor species, the most conservative value was used in the risk calculations regardless of the toxic mechanism. Toxicity values obtained from long-term feeding studies were preferable to those obtained from single dose oral studies.

- Some doses were originally reported as part per million contaminants in a diet. These were converted to daily intakes (in mg/kg-day) by using the following formula:

  Daily Intake (mg/kg-day) = ECOC dose (mg/kg diet) x Ingestion Rate (kg/day) x 1/body weight (kg)

With this formula, dietary toxicity levels cited for species were converted to a daily dose based on body weight. For this ecological RA, incidental soil/sediment ingestion was also included in the calculation to determine the total daily intake for the receptor species. This daily dose may then be used to evaluate the risk to other species if no specific toxicity data are available for a target receptor.

7.3 Exposure Profile

Receptor species were selected based on two primary requirements: 1) the species potentially may inhabit Sites 1 and 3, and 2) the species represent various trophic levels in the food chain. Table 7-8

provides the inputs used in the receptor models for Sites 1 and 3. Both conservative and less conservative inputs (if available) for each of modeled species were used to determine potential risks. The following subsections provide brief descriptive life histories for the receptor species.

7.3.1 Largemouth Bass (*Micropterus salmoides*)

Largemouth bass feed primarily on other fishes. The bass inhabits quiet, clear to slightly turbid streams, ponds, lakes, and reservoirs, often with vegetation.

7.3.2 Great Blue Heron (*Ardea herodias*)

The great blue heron inhabits freshwater lakes and rivers, brackish marshes, lagoons, mangroves, and coastal waters. The heron inhabits areas where small fish are plentiful in shallow water. Herons are medium to large-sized wading birds with long necks and spear-like bills. The diet of the great blue heron consists primarily of fish, but also includes amphibians, reptiles, crustaceans, insects, birds, and mammals. In the northern portion of the United States, herons are migratory, moving south for the winter. The home range of the heron ranges from 0 up to 24 kilometers (USEPA, 1993).

7.3.3 Bullfrog (*Rana catesbeiana*)

Adult bullfrogs inhabit the edges of ponds, lakes, and slow-moving streams. The bullfrog prefers to inhabit permanent bodies of water where the tadpoles can develop. Bullfrogs consume water weeds and insects, crayfish, other frogs, tadpoles, minnows, snails, young turtles, and occasionally small birds, mammals, and young snakes. As noted on Table 7-8, water ingestion rates were not found for the bullfrog. The home range of the bullfrog ranges from 0.61 to 11.3 meters (USEPA, 1993).

7.3.4 American Woodcock (*Scolopax minor*)

American woodcocks are inland members of the sandpiper family. They have a stocky build, long bills, and short legs. Woodcocks inhabit woodlands and abandoned fields, especially those with rich and moderately to poorly drained loamy soils. Woodcocks feed mainly on earthworms and other

soil invertebrates found in moist soil by probing the soil with their bill. The home range of the American woodcock ranges from 0.3 to 24.1 hectares (USEPA, 1993).

7.3.5 Red-Tailed Hawk (*Buteo jamaicensis*)

Red-tailed hawks inhabit woodlands, wetlands, pastures, prairies, and deserts. The hawk prefers a mixed landscape of open fields and woodlands. The red-tailed hawk is a bird of prey that consumes ground-dwelling vertebrates, particularly rodents and small mammals. Small mammals comprise the most significant portion of the hawk's diet. The home range for the hawk can range from a few hundred hectares to well more than 1,500 hectares, depending on the habitat. The more northerly red-tailed hawks are migratory while the southerly hawks are year-round inhabitants (USEPA, 1993).

7.3.6 American Robin (*Turdus migratorius*)

American robins are common, medium-sized birds. They inhabit areas where they have access to freshwater, protected nesting areas, and productive forage areas. The robin inhabits moist woodlands, swamps, orchards, parks, and lawns. American robins primarily eat worms, insects, and fruit. The home range of the robin ranges from 0.12 to 0.84 hectares. Most northern robins migrate south for the winter (USEPA, 1993).

7.3.7 Marsh Wren (*Cistothorus palustris*)

Marsh wrens are small insectivorous birds with long, slender bills used to glean insects from the ground and vegetation. The marsh wren inhabits freshwater and saltwater marshes, usually nesting in areas with bulrushes, cattails, and sedges. Wrens consume aquatic invertebrates, and other insects and spiders. The marsh wren was selected as a surrogate species for the warbler. The wren and warbler have similar sizes and ingestion rates. Because the wren was used as a surrogate for the warbler, the model was run using surface water and surface soil inputs (terrestrial), as opposed to using sediment (aquatic). Wrens are year-round residents in areas where marshes do not freeze in the winter. Marsh areas that are less than 0.4 hectares are typically not inhabited by breeding marsh wren. Home range size for the male wren is from 0.006 to 17 hectares depending on the habitat (USEPA, 1993).

7.3.8 Red Fox (*Vulpes vulpes*)

Red foxes extensively prey on mice and voles but may also consume other small mammals, insects, hares, game birds, poultry, berries, and fruits. They can live in habitats ranging from arctic areas to temperate deserts. Red foxes live in cropland, farmland, brush, pastures, hardwood stands, and coniferous forests. Foxes prefer areas with broken and diverse upland habitats. Foxes tend not to inhabit continuous stands of pine forests in the southeast, moist conifer forests along the Pacific coast, and semiarid grasslands and deserts. Home ranges of foxes within the same family overlap, creating family territory. Territory sizes range from 50 to more than 3,000 hectares (USEPA, 1993).

7.3.9 Short-Tailed Shrew (*Blarina brevicauda*)

Short-tailed shrews inhabit a variety of habitats and are most commonly found in areas with abundant vegetation. The shrew prefers cool, moist habitats because of their high metabolic and water-loss rates. The northern short-tailed shrew is a small insectivorous mammal that eats insects, worms, snails, and other vertebrates. Shrews may also consume mice, voles, frogs, and other vertebrates. Shrews have high metabolic rates and can eat approximately their weight in food each day. Shrews have high mortality rates in the winter, ranging from 70 to 90 percent (USEPA, 1993). The home range of the shrew varies from 0.03 to 0.07 hectares at high prey densities to 1 to 2.2 hectares at low prey densities with a minimum territory overlap (USEPA, 1993).

7.3.10 Meadow Vole (*Microtus pennsylvanicus*)

Meadow voles inhabit grassy fields, marshes, and bogs. The vole is mainly a herbivore feeding primarily on shoots, grasses, seeds, roots, fungi, and bark. Voles may also consume insects and animal matter. The home range of meadow voles is from 0.0002 to 0.083 hectares, depending on the population of predators (mainly the shrew) (USEPA, 1993).

7.3.11 Deer Mouse (*Peromyscus meniculatus*)

Deer mice are small, ground-dwelling rodents that live in a large variety of habitats including woodlands, prairies, rocky habitats, tundra, and deserts. The mice usually occupy dry-land habitats, short-grass prairies, grass-sage communities, coastal sage scrub, sand dunes, wet prairies, upland

mixed and cedar forests, deciduous forests, juniper forests, and coniferous forests. They are nocturnal and are preyed on by hawks, owls, snakes, and carnivorous mammals. Deer mice are omnivorous and highly opportunistic. They eat primarily seeds, but also arthropods, green vegetation, roots, fruits, and fungi. Some deer mice occupy more than one nest. Most of the nests are found in tree hollows above ground, but also around roots and under logs and rocks. The home range of deer mice ranges from 0.054 to 0.072 hectares (USEPA, 1993).

7.4 Effects Profile

Contaminants that exceed screening levels are assumed to potentially be adversely impacting receptor species and adversely impacting species, populations, and communities in the aquatic and terrestrial ecosystems at Sites 1 and 3.

A literature search was conducted to determine levels of exposure of contaminants at which no adverse effects would be expected. The NOAEL and Lowest Observed Adverse Effect Level (LOAEL) values used are presented on Tables 7-9, 7-10, and 7-11 for the terrestrial species at Site 1, the terrestrial species at Site 3, and the aquatic species at Sites 1 and 3, respectively. The studies from which the values were developed are presented in Appendix 7A.

7.5 Risk Characterization

The hazard quotient (HQ) method was used to estimate potential risks to ecological receptors at Sites 1 and 3. This method compares exposure concentrations with ecological endpoints such as reproductive failure or reduced growth. The following equation was used to calculate HQs at Sites 1 and 3:

$$Hazard\ Quotient = \frac{Maximum\ Exposure\ Concentration}{NOAEL\ or\ Other\ Benchmark\ Value}$$

An HQ greater than one indicates that exposure to the contaminant has the potential to cause adverse effects to the species. An HQ less than one indicates that the contaminant is not expected to cause adverse effects to the species. The HQ for each ECOC was assessed for this ecological RA.

7.6 Uncertainty Analysis

The procedures used in this evaluation to assess risks to ecological receptors, as in all such assessments, are subject to uncertainties. The following subsections discuss the uncertainty in this ecological RA associated with the sampling methods, use of background screening levels, and receptor models.

7.6.1 Sampling Method

The Round Two ecological investigation consisted of one sampling effort. The results of this sampling will only provide a "snapshot in time" of the ecological environment.

7.6.2 Use of Background Concentrations

There is uncertainty involved with the use of background data in the ecological RA. Surface soil, surface water, and sediment data collected within the York River Basin were used qualitatively to assess contaminant concentrations detected at Sites 1 and 3. The normal 95% upper confidence levels (UCLs) for background concentrations were used for the comparison. Background areas were selected to represent regional conditions. Consideration was taken in the selection of background areas to select areas that appeared to be relatively unimpacted by surrounding land use. However, achieving background levels in the York River Basin that are completely uninfluenced by anthropogenic conditions may be impossible. Therefore, background areas represent both the natural regional conditions and any baseline anthropogenic conditions in the area.

7.6.3 Screening Levels

Potential adverse impacts to terrestrial flora and fauna were evaluated by comparing the ECOC concentrations to surface soil benchmark values obtained in literature references. There is uncertainty assessing the terrestrial environment using these benchmark values. Most of these studies do not take into account soil type, which may have a great influence on the toxicity of the contaminants. For example, soil with high organic carbon content will tend to absorb many of the organic ECOCs, thus making them less bioavailable to terrestrial receptors. Also, various inorganic compounds in surface soil tend to have high degrees of variability. The variability of the inorganic

concentrations in surface soil in turn magnifies the uncertainty associated with using the literature toxicity values to assess the risk posed to the terrestrial environment.

The benchmark values are based on both field and growth chamber studies; therefore, the reported toxic concentrations are not always equivalent to actual field conditions. In addition, most of the benchmark values used for comparison purposes had low levels of confidence assigned to the values based on the low number of studies performed (less than ten studies) and the lack of diversity of species tested.

There is uncertainty in the ecological endpoint comparison. The surface water screening levels are established to be protective of most of the potential receptors. However, some species will not be protected by the values because of their increased sensitivity to the chemicals. For example, the Ambient Water Quality Criteria developed by the United States Environmental Protection Agency (USEPA) in theory only protect 95 percent of the exposed species. Therefore, there may be some sensitive species present that may not be protected with these criteria. In addition, most of the values are established using laboratory tests, where the concentrations of certain water quality parameters (pH, total organic carbon) that may influence toxicity are most likely at different concentrations than in the site water.

Potential adverse impacts to aquatic receptors from contaminants in the sediment were evaluated by comparing the ECOC concentration in the sediment to sediment screening levels. These SSLs have more uncertainty associated with them than do the SWSLs, since the procedures for developing them are not as established as those used in developing SWSLs. In addition, sediment type (pH, acid volatile sulfide, total organic carbon) has a significant impact on the bioavailability and toxicity of contaminants. The SSLs were developed using data obtained from freshwater, estuarine, and marine environments. Therefore, their applicability for use to evaluate potential effects to aquatic organisms from contaminants in freshwater habitats introduces uncertainty because of differences in both the toxicity of individual contaminants to freshwater and saltwater organisms and the bioavailability of contaminants in the two aquatic systems.

Several contaminants detected at Sites 1 and 3 do not have screening levels or benchmark values available to evaluate the detected concentrations. The contaminants without screening levels were retained as ECOCs, but were not quantitatively evaluated in this ecological RA. Nevertheless, these

contaminants may be contaminants of concern at the site. The following contaminants detected at Sites 1 and 3 do not have screening levels available to evaluate detected concentrations: butylbenzylphthalate, carbazole, dibenzofuran, and 2-methylnaphthalene in surface soil (potential risks to flora and fauna); aluminum and iron in the surface water (potential risks to aquatic species); and aluminum, cobalt, and vanadium in the sediment (potential risks to benthic macroinvertebrates).

In addition, the toxicity of chemical mixtures is not well understood. All the toxicity information used in the ecological RA for evaluating risk to the ecological receptors is for individual chemicals. Chemical mixtures can affect the organisms very differently than the individual chemicals due to synergistic or antagonistic effects. In addition, the species used to develop the toxicity data may not be present at the site, or have the potential to exist at the site. Depending on the sensitivity of the tested species to the species at the site, use of the toxicity values may overestimate or underestimate risk.

7.6.4 Ecological Receptor Models

There are some differences of opinion found in the literature as to the effectiveness of using models to predict concentrations of contaminants found in ecological species. According to one source, the food chain models currently used incorporate simplistic assumptions that may not represent conditions at the site, bioavailability of contaminants, or site-specific behavior of the receptors.

Simple food chain models can provide an effective means of initial characterization of risk; however, residue analyses, toxicity tests, and the use of biomarkers provide a better approach for assessing exposure (Menzie et al., 1993). There is uncertainty with the simple assumptions made within the models. For example, the use of a BSAF value of one may not adequately represent actual contaminant characteristics. Depending on the ECOC, a BSAF may err on the conservative or not so conservative end of the spectrum.

Literature values for the toxicity of ECOCs were not available for all of the receptor species. An attempt was made to identify studies using related species in order to make risk estimates as accurate as possible. In particular, toxicity values for the largemouth bass and bullfrog models were not available for many parameters. Therefore, many ECOCs identified at Sites 1 and 3 could not be assessed in these models.

In some instances, NOAEL values were not found in the literature. If NOAEL values were not reported, then LOAEL or LD_{50} values were used to calculate a NOAEL. A LOAEL was divided by a factor of ten and an LD_{50} was divided by a factor of 100 to obtain NOAEL values. There is uncertainty in this calculation of NOAELs; however, the uncertainty most likely errs on the conservative side.

Doses in toxicological studies are typically reported in units of mg of contaminant/kg diet, or in units of mg contaminant/kg body weight/day. All doses reported as mg/kg in diet were converted to units of mg/kg-body weight/day. If body weights were reported for the test animals in a given study, these values were used for making this conversion. Otherwise, the body weight and ingestion rate for the species reported in other literature sources were used.

There is uncertainty associated with some of the toxicity values derived from a single species, single contaminant study. Prediction of ecosystem effects from laboratory studies is difficult. Laboratory studies cannot take into account the effects of environmental factors which may add to the effects of contaminant stress. NOAELs were generally selected from studies using single contaminant exposure scenarios.

There is uncertainty in the total daily intake models used to evaluate a reduction of receptor populations or sub-populations. Many input parameters are based on default values (i.e., ingestion rates) that may or may not adequately represent the actual values of the parameters. In addition, there is uncertainty in the level to which the indicator species will represent other species potentially exposed to ECOCs at the site.

7.7 Results

This section presents the results of the ecological RA for Sites 1 and 3. The results were determined by a comparison of surface soil, surface water, and sediment site data to benchmark criteria. In addition, the daily intake receptor models were used to assess potential risks to higher trophic species.

7.7.1 Site 1

At Site 1, surface soil was evaluated to determine potential risks to ecological receptors. The following subsections present the risks associated with the surface soil and the terrestrial models calculated for this site. It is noted that the receptor models were calculated using Site 1 surface soil data and Indian Field Creek (Sites 1 and 3) surface water data as inputs.

7.7.1.1 Comparison to Benchmark Toxicity Values

Maximum detected concentrations of the ECOCs were compared with benchmark toxicity values developed for the protection of surface soil flora, invertebrates, earthworms, microorganisms, and micro processes. As presented on Table 7-12, surface soil benchmarks were not found for most of the SVOCs or 2,4-dinitrotoluene. The soil collected at Site 1 did not exceed the available SVOC toxicity benchmark values.

Of the inorganics, concentrations of aluminum, chromium, lead, and vanadium were above flora benchmark values. The highest flora HQs were calculated for aluminum (224.0) and chromium (12.4). Inorganic concentrations of aluminum, chromium, iron, and lead exceeded established benchmark values for soil fauna. The highest fauna HQs were calculated for chromium (82.7) and iron (58.5).

Surface soil concentrations of aluminum, chromium, iron, and vanadium were detected below the 95% UCL background concentrations. Lead concentrations at Site 1 exceeded the background UCL. The surface soil ECOCs identified at Site 1 were further assessed in the receptor models presented below.

7.7.1.2 Terrestrial Receptor Models

The input parameters for the receptor models calculated for Sites 1 and 3 are presented on Table 7-8. The NOAELs and the LOAELs used in the receptor models for Site 1 are presented on Table 7-9.

Tables 7-13 through 7-16 present the receptor models calculated for mean concentrations, maximum concentrations, conservative inputs, and less conservative inputs for the terrestrial species at Site 1.

Table 7-17 summarizes the most conservative and least conservative HQs calculated for the terrestrial species. The HQs are divided into three categories: those greater than 100, those between 100 and 10, and those between 10 and 1. The three categories do not necessarily indicate a range of risk levels, since any contaminant with an HQ greater than one indicates a potential risk to the modeled species. However, it does give an indication regarding which ECOCs are driving the risk.

Inorganics were the only ECOCs that had HQs greater than one at Site 1. Overall, under the most conservative exposure scenario, aluminum, chromium, copper, iron and lead had HQs greater than one in all the species, followed by vanadium (six species) and zinc (five species). Aluminum and lead had HQs greater than 100 in five species. Chromium had HQs greater than 100 in four species. Copper and iron had HQs greater than 100 in one and three species, respectively.

Overall, under the least conservative exposure scenario, aluminum and iron had HQs greater than one in six of the species, followed by chromium and lead (five species), vanadium (three species), and copper (two species). Aluminum was the only ECOC with an HQ greater than 100 (one species), and aluminum and chromium were the only ECOCs that had HQs between 10 and 100 (three species).

Copper, lead, and zinc were the only inorganics with HQs greater than one (using the most conservative exposure scenario) that exceeded background concentrations. All of the species had HQs greater than one for these ECOCs (most conservative). Zinc did not have an HQ greater than one in the least conservative model. The woodcock, vole, shrew, robin, and mouse were the only species with HQs greater than one (least conservative) that exceeded background concentrations.

7.7.2 Site 3

At Site 3, a surface soil AOC was identified and evaluated separately from the remainder of the site (Site 3 Proper). Initially, terrestrial receptor models were calculated for the entire site to determine if an overall terrestrial risk existed at Site 3. The receptor models calculated for the entire site are presented in Appendix 7B. The following subsections present the results of the terrestrial assessment conducted in Site 3 Proper and the Soil AOC. Surface water data collected from Indian Field Creek (Sites 1 and 3) were used in the receptor models. The following sections present the results of the terrestrial assessment conducted at Site 3.

7.7.2.1 Site 3 Proper

The surface soil data collected from Site 3 Proper were evaluated to determine potential risks to the terrestrial environment at the site outside the Soil AOC. The following subsections present the results of the comparison to flora and fauna benchmark values and the results of the terrestrial models calculated for this area.

Comparison to Benchmark Criteria

Maximum detected concentrations of the ECOCs were compared with benchmark toxicity values developed for the protection of surface soil flora, invertebrates, earthworms, microorganisms, and micro processes. As presented on Table 7-18, surface soil benchmarks were not found for most of the SVOCs and cyanide. It is noted that cyanide was not detected in background surface soil samples. The soil collected at Site 3 did not exceed the available SVOC toxicity benchmark values.

Of the inorganics, concentrations of aluminum, antimony, chromium, lead, manganese, mercury, thallium, vanadium, and zinc were above flora benchmark values. The highest flora HQ was calculated for aluminum (236.0), followed by antimony (33.6). Inorganic concentrations of aluminum, chromium, iron, manganese, mercury, vanadium, and zinc exceeded benchmark values established for soil fauna. The highest fauna HQs were calculated for chromium (210.7) and iron (119.0).

Surface soil concentrations of aluminum and iron were below background UCL concentrations. Concentrations of antimony, chromium, lead, manganese, mercury, thallium, vanadium, and zinc in Site 3 Proper exceeded background UCL concentrations. The surface soil ECOCs identified at Site 3 were further assessed in the receptor models presented below.

Terrestrial Receptor Models

The LOAELs and NOAELs used in the receptor models are presented on Table 7-10. Tables 7-19 through 7-22 present the terrestrial models calculated for Site 3 Proper.

Table 7-23 summarizes the most conservative and least conservative HQs calculated for the terrestrial species. Inorganics were the only ECOCs that had HQs greater than one. Overall, under the most conservative exposure scenario, aluminum, chromium, copper, iron, lead, vanadium, and zinc had HQs greater than one in all the species, followed by vanadium (seven species), mercury (six species), manganese (five species), and antimony (four species). Chromium had HQs greater than 100 in all eight species, followed by aluminum, iron, and lead which had HQs greater than 100 in six species. Antimony and copper had HQs greater than 100 in two and one species, respectively.

Overall, under the least conservative exposure scenario, iron had HQs greater than one in seven species, followed by aluminum, chromium, and lead (six species), antimony and vanadium (three species), and copper (two species) Aluminum was the only ECOC with an HQ greater than 100 (one species). Aluminum (three species), chromium (four species), and iron (two species) generated HQs between 10 and 100 in the least conservative exposure scenario. Several metals had HQs between 1 and 10.

Antimony, beryllium, chromium, copper, lead, manganese, mercury, vanadium, and zinc had HQs greater one and exceeded background UCL concentrations (using the most conservative exposure scenario). In the least conservative models, antimony, chromium, copper, lead, and vanadium had HQs greater than one and exceeded background UCL concentrations.

7.7.2.2 Site 3 - Soil Area of Concern

The surface soil collected in the Soil AOC at Site 3 was separated from the remainder of the site to determine potential terrestrial risks posed by this area. The following subsections present a comparison to flora and fauna toxicity values and the results of the terrestrial receptor modeling.

Comparison to Benchmark Criteria

Maximum detected concentrations of the ECOCs were compared with benchmark toxicity values developed for the protection of surface soil flora, invertebrates, earthworms, microorganisms, and micro processes. As presented on Table 7-24, surface soil benchmarks were not found for most of the SVOCs. Surface soil concentrations of benzo(a)pyrene and phenanthrene exceeded toxicity

benchmark values for the protection of soil fauna [HQs of 3.1 for benzo(a)pyrene and 2.0 for phenanthrene].

It is noted that only one sample analyzed for inorganics is associated with the Soil AOC. Of the inorganics, concentrations of aluminum, chromium, lead, manganese, mercury, vanadium, and zinc were above flora benchmark values. The highest flora HQ was calculated for aluminum (202.0), followed by vanadium (71.0). Inorganic concentrations of aluminum, chromium, iron, manganese, mercury, vanadium, and zinc exceeded benchmark values established for soil fauna. The highest fauna HQs were calculated for manganese (158.0) and chromium (106.7).

Surface soil concentrations of aluminum, chromium, and iron were below background UCL concentrations. Concentrations of lead, manganese, mercury, vanadium, and zinc in the Soil AOC exceeded background UCL concentrations. The surface soil ECOCs identified in this area were further assessed in the receptor models presented below.

Terrestrial Receptor Models

It is noted that the samples in this AOC included six samples analyzed for SVOCs and one sample for volatiles, pesticides/PCB, nitramines, and inorganics. The LOAELs and NOAELs used in the receptor models are presented on Table 7-10.
Tables 7-25 through 7-28 present the terrestrial models for the Soil AOC at Site 3.

Table 7-29 summarizes the most conservative and least conservative HQs calculated for the terrestrial species. Inorganics and PAHs were the only ECOCs that had HQs greater than one. Overall, under the most conservative exposure scenario, aluminum, chromium, copper, iron, lead, vanadium and PAHs had HQs greater than one in all the species, followed by mercury and zinc (seven species), manganese (six species), and beryllium (one species). Aluminum, chromium, and lead had HQs greater than 100 in five species, followed by iron and vanadium which had HQs greater than 100 in two species and three species, respectively. Two PAHs had HQs greater than 100 in one species. Several inorganics and PAHs had HQs between 1 and 100 in all of the species.

Overall, under the least conservative exposure scenario, aluminum, chromium, iron and lead had the most HQs greater than one (seven species), followed by vanadium (six species), PAHs (five species),

copper (three species), mercury (two species), and manganese (one species). Aluminum (three species) and chromium (one species) were the only ECOCs with an HQ greater than 100. Several inorganics and PAHs had HQs between 1 and 100.

PAHs, copper, lead, manganese, mercury, vanadium, and zinc had HQs greater one and exceeded background concentrations (using the most and least conservative exposure scenarios).

7.7.3 Sites 1 and 3

An aquatic ecological RA was conducted on the surface water and sediment collected from Indian Field Creek at Sites 1 and 3. The following subsections present the results of this assessment.

7.7.3.1 Comparison to Benchmark Criteria

Maximum concentrations of the ECOCs detected in the surface water and sediment collected from Indian Field Creek at Sites 1 and 3 were compared with available tidal freshwater surface water and sediment benchmark values.

Surface Water

As displayed on Table 7-30, copper was detected higher than the benchmark value for aquatic organisms (HQ = 3.79). It is noted that estuarine benchmarks were not located for aluminum, iron, and manganese. Surface water concentrations of zinc were below surface water toxicity values. It is noted that the detected concentrations of aluminum, iron, and manganese were below off-station, tidal freshwater, background surface water UCL concentrations. Surface water concentrations of copper and zinc exceeded background UCL concentrations.

Sediment

As shown on Table 7-31, cadmium, iron, and manganese exceeded sediment benchmark values. The HQs calculated for these three inorganics were similar: 1.67 for cadmium, 1.45 for iron, and 1.65 for manganese. There were no benchmark values available to assess the site concentrations of aluminum, cobalt, and vanadium. Sediment concentrations of aluminum, cobalt, manganese, and

nickel at Sites 1 and 3 were below the background UCL concentrations. Concentrations of iron and vanadium were above background UCL concentrations, while the HQ calculated for vanadium only slightly exceeded the background UCL.

Maximum and mean sediment concentrations of the surface water and sediment ECOCs were used in the calculation of risks to receptor models for Sites 1 and 3.

7.7.3.2 Aquatic Receptor Models

Tables 7-32 through 7-35 present the aquatic receptor models for Sites 1 and 3. The LOAELs and NOAELs used in the aquatic models are presented on Table 7-11. As presented below, the risks to aquatic receptors at Sites 1 and 3 are caused by sediment concentrations of lead detected slightly above background concentrations.

Table 7-36 summarizes the most conservative and least conservative HQ calculated for the aquatic species modeled for Indian Field Creek. It is noted that due to the limited number of NOAELs and LOAELs available, none of the ECOCs could be evaluated in the fish model. Hazard quotients were calculated greater than one in the heron model for aluminum, arsenic, cadmium, cobalt, copper, iron, lead, vanadium, and zinc. In the most conservative exposure scenario, iron in the heron model produced an HQ greater than one hundred. Aluminum, arsenic, copper, and lead had HQs between 10 and 100 and cobalt, vanadium, and zinc had HQs between 1 and 10 in the most conservative heron model.

In the least conservative model, aluminum, copper, iron, and lead had HQs greater than one, but less than ten. Of these inorganics, copper, iron, and lead were detected above background.

7.8 Ecological Risk Assessment Summary

Figures 7-1, 7-2, and 7-3 present the ECOCs detected in surface soil and sediment that drive receptor risk and were detected above background UCLs. It is noted that ECOCs not detected or detected below background UCLs were not presented on the figures. The following subsections provided a brief overview of the potential ecological risks identified in this RA for each site.

7.8.1 Site 1 - Terrestrial Environment

Based on a screening of soil concentrations against flora/fauna toxicity values, the terrestrial environment at Site 1 is impacted by soil concentrations of aluminum, chromium, iron, lead, and vanadium. In addition, receptor models calculated for Site 1 demonstrated risks from surface soil concentrations of aluminum, chromium, copper, iron, lead, and vanadium. Site 1 surface soil concentrations of aluminum, chromium, iron, and vanadium were detected below background UCL concentrations.

Site 1 surface soil concentrations of copper and lead were detected above background UCL concentrations. Surface soil concentrations of copper detected at Site 1 were below the surface soil screening level. Copper was included in the models because it was a surface water ECOC.

7.8.2 Site 3 - Terrestrial Environment

The terrestrial flora and fauna environment in Site 3 Proper is adversely influenced by soil concentrations of aluminum, antimony, chromium, iron, lead, manganese, mercury, thallium, vanadium, and zinc. Receptor models displayed risks from surface soil concentrations of aluminum, antimony, chromium, copper, iron, lead, and vanadium. The surface soil concentrations of aluminum and iron in Site 3 Proper were detected below background UCL concentrations. Whereas, concentrations of antimony, chromium, copper, lead, manganese, mercury, thallium, vanadium, and zinc were detected above background UCL concentrations. Although, copper was detected above background, the soil concentrations in Site 3 Proper were below screening levels. Copper was retained in the terrestrial models because it was a surface water ECOC.

The terrestrial flora and fauna community in the Soil AOC is adversely influenced by soil concentrations of SVOCs, aluminum, chromium, iron, lead, manganese, mercury, vanadium, and zinc. Receptor model species may be adversely impacted by surface soil concentrations of SVOCs, aluminum, chromium, copper, iron, lead, manganese, mercury, vanadium, and zinc. These compounds were detected above background concentrations, exceeded flora/fauna toxicity values, or generated risks in the terrestrial models.

7.8.3 Sites 1 and 3 - Aquatic Environment

The aquatic environment at Sites 1 and 3 is adversely affected by surface water concentrations of aluminum, copper, and iron. Aluminum and iron concentrations at Sites 1 and 3 were below background UCL concentrations. Copper exceeded the background UCL concentration. Surface water concentrations contribute to risks in the aquatic receptor models; however, sediment concentrations are the primary risk drivers.

Based on slight exceedances of benchmarks, sediment concentrations of cadmium, iron, and manganese potentially may adversely affect the benthic macroinvertebrate community at Sites 1 and 3. In addition, other aquatic receptors inhabiting Sites 1 and 3 may be adversely impacted by aluminum, copper, iron, and lead, as indicated by the receptor models. It is noted that sediment concentrations of aluminum and manganese are below background UCL concentrations. It is noted that copper was detected below sediment screening levels, but was retained in the receptor models because it is a surface water ECOC. Sediment concentrations of iron and lead were detected above background UCL concentrations.

7.9 References

Baker. Baker Environmental, Incorporated. 1995a. Final Habitat Evaluation Report, Sites 1, 2, 3, 4, 6, 7, 8, 9, 11, 12, 16, 17, 18, 19, and 21, Naval Weapons Station Yorktown, Yorktown, Virginia. July 1995.

Baker. Baker Environmental, Incorporated. 1995b. Summary of Background Constituent Concentrations and Characterization of the Biotic Community from the York River Drainage Basin, Naval Weapons Station Yorktown, Yorktown, Virginia. March 1995.

Beyer, N., E. Connor, and S. Gerould. 1993. "Estimates of Soil Ingestion by Wildlife." Patuxent Wildlife Research Center, Laurel, MD.

Boschung, Herbert T., James D. Williams, Daniel W. Gotshall, Melba C. Caldwell, and David K. Caldwell. 1983. The Audubon Society Field Guide to North American Fishes, Whales, and Dolphins. Alfred A. Knopf, Inf. New York.

Browmer, D.T., P. Roza, L. Henzen, and C. Degeling. 1993. "The development of chronic toxicological tests for PAH contaminated soils using the earthworm *Eisenia fetida* and the Springtail *Folsomia candida*." Report IMW-R 92/387. TNO Institute of Environmental Sciences, Delft, the Netherlands. Cited in Brummelen et al., 1996.

Brummelen, T.C., A.M. van Gestel Cornelis, and Rudo A. Verweij. 1996. "Long-term toxicity of five polycyclic aromatic hydrocarbons for the terrestrial isopods *Oniscus asellus* and *Porcellio scaber*." Environmental Toxicology and Chemistry Vol 15, No. 7, pp 119-1210.

Buhlman, K.A. and J.C. Ludwig. 1992. A Natural Heritage Resources Inventory of the Naval Weapons Station Yorktown, Department of the Navy Yorktown, Virginia. Natural Heritage Technical Report #92-18, Department of Conservation and Recreation, Division of Natural Heritage. Richmond, Virginia. 31 March 1992. pp36.

Burt, W.H. and R.P. Grossenheider. 1980. A Field Guide to Mammals of North America, North Mexico. Boston, MA: Houghton Mifflin, Co.

Calder, W.A. and E.J. Braun. 1983. "Scaling of osmotic regulation in mammals and birds." American Journal of Physiology. 244:R601-R606.

Clench, M.H. and R.C. Leberman. 1978. "Weights of 151 bird species of Pennsylvania birds analyzed by month, age, and sex." Bull. Carnegie Mus. Nat. Hist.

Cronin, K.L. and E.L. Bradley. 1988. Population ecology and home range utilizations of two subalpine meadow rodents Microtus longicaudus) and *Peromyscus maniculatus*. In: Merrit, J.F. (ed.) Winter Ecology of Small Mammals. V10. Spec. Publ. Carnegie Mus. Nat. Hist. New York.

Ehrlich, P.R., D.S. Dobkin, and D. Wheye. 1988. The Birders Handbook. Simon and Schuster, Fireside. New York. 785p.

Fitchko, J. 1989. Criteria for Contaminated Soil/Sediment Cleanup. Pudvan Publishing Co., Inc. Northbrook IL.

Guilday, J.E. 1957. "Individual and geographic variation in *Blarina brevicauda* from Pennsylvania. " Ann. Carnegie Mus. 35:41-68.

Kirkwood, J.K. 1980. "Maintenance energy requirements and rate of weight loss during starvation in birds of prey." Recent Advancements in the Study of Raptor Diseases. Proceedings of the International Symposium on Diseases of Birds of Prey. J.E. Cooper and A.G. Greenwood (eds.). London.

Kushlan, J.A. 1978. "Feeding ecology in wading birds." In: Sprunt, A., Ogden, J.: Wincler, S., eds. Wading birds. Natl. Audubon Soc. Res. Rep. 7; p 249-296.

Long, Edward R., Donald D. Mac Donald, Sherri L. Smith, and Fred Calder. 1995. "Incidence of Adverse Biological Effects Within Ranges of Chemical Concentrations in Marine and Estuarine Sediment." Environmental Management. Volume 19.

Long, E. R., and L.G. Morgan. 1991. "The potential for biological effects of sediment-sorbed contaminants tested in the National Status and Trends Program." NOAA Technical Memorandum. NOS OMA 62. National Oceanic and Atmospheric Administration, Seattle, WA.

Marshall (unpublished) as cited in Sheldon, W.G. 1976. The Book the American Woodcock. Amerst, MA: University of Massachusetts Press.

McAlpine, D.F. and T.G. Dilworth. 1989. "Microhabitat and prey size among three species of *Rana* (Anura: Ranidae) sympatric in eastern Canada." Can. J. Zool. 67:2241-2252.

Menzie, C.A., Cura J., and J. Freshman. 1993. Evaluating Ecological Risks and Developing Remedial Objectives at Forested Wetland Systems in New England. Paper contained in: Application of Ecological Risk Assessment to Hazardous Waste site Remediation. Water Environment Federation. January 1993.

Merritt, J.F. 1987. Guide to Mammals of Pennsylvania. Univ. Pittsburgh Press, PA 408p.

Millar, J.S. and D.G. Innes. "Demographic and life cycle characteristics of montane deer mice." Can. J. Zool. 61:574-585.

Myers, J.H. and C.J. Krebs. 1971. "Genetic, behavioral, and reproductive attributes of dispersing field moles *Microtus pennsylvanicus* and *Microtus ochrogaster*." Ecol. Monogr. 41:53-78.

Newell, Arthur J., David W. Johnson, and Laurie K. Allen. 1987. Niagara River Biota Contamination Project: Fish Flesh Criteria for Piscivorous Wildlife. Division of Fish and Wildlife. The Bureau of Environmental Protection. July 1987.

NRC. National Research Council. 1993. "Nutrient requirements of Fish." NRC, Committee on Animal Nutrition, Board of Agriculture. National Academy Press, Washington, D.C. 114p.

Opresko, D.M., B.E. Sample, and G.W. Suter. 1993. Toxicological Benchmarks for Wildlife. Oak Ridge National Laboratory. ES/ER TM-86. September 1993.

ORNL. Oak Ridge National Laboratory. 1996. Screening Benchmarks for Ecological Risk Assessment (Database, Version 1.6). Environmental Sciences and Health Sciences Research Division. Oak Ridge, Tennessee.

Pflieger, W.L. 1975. The Fishes of Missouri. Missouri Department of Conservation.

Quinney, T.E. 1982. "Growth, diet, and mortality of nestling great blue herons." Wilson Bull. 95:571-577.

Samuel, D.E. and B.B. Nelson. 1982. Foxes (*Vulpes vulpes* and Allies) In: The Wild Mammals of North America: Biology, Management, Economics. J. Chapman and G. Feldhamer (eds). John Hopkins Press, Baltimore, M.D.

Sargeant, A.B. "Red fox prey demands and implications to prairie duck production." J. Wildl. Manage. 42:520-527.

Schlesinger, W.H. and G.L. Potter. 1974. "Lead, copper, and cadmium concentrations in small mammals in the Hubbard Brook Experimental Forest." Oikes 25:148-152.

Sheldon, W.G. 1967. The Book of the American Woodcock. Amherst, MA: University of Massachusetts Press. 227p.

Steenhof, K. and M.N. Kochert. 1985. "Dietary shifts of sympatric buteos during a prey decline." Oecologia 66:6-16.

Storm, G.L., R.D. Andrews, R.L. Phillips, et al. 1976. "Morphology, reproduction, dispersal and mortality of midwestern red fox populations." Wildl. Monogr. 49:1-82.

Subcommittee on Mineral Toxicity in Animals. 1992. Mineral Tolerance of Domestic Animals. National Academy of Sciences. Washington, D.C. pp 5-7.

Sullivan, J.J. Ball, E. Brick, S. Hausman, G. Pilarski, and D. Sopcich. 1985. Report for the Technical Subcommittee on Determination of Dredge Material Suitability for In-Water Disposal. Wisconsin Department of Natural Resources. Cited in: Fitchko. 1989.

SCDM. Superfund Chemical Data Matrix. 1991. United States Environmental Protection Agency Hazardous Site Evaluation Division. December 1991.

Suter II, G.W. and C.L. Tsao. 1996. Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Aquatic Biota: 1996. Prepared by Risk Assessment Program, Health Sciences Research Division, Oak Ridge, Tennessee. For the U.S. Department of Energy, Office of Environmental Management. ES/ER/TM-96/R2. June 1996.

Tetra Tech, Inc. 1986. Development of Sediment Quality Values for Puget Sound, Volume I. Puget Sound Dredged Disposal Analysis Report. Cited in: Fitchko. 1989.

Tintle (unpublished) as cited in Dunning, J.B., Jr. 1984. "Body weights of 686 species of North American birds." Western Banding Association, Monograph No. 1. Cave Creek, AZ: Eldon Publishing.

USEPA. United States Environmental Protection Agency. 1996. Proposed Guidelines for Ecological Risk Assessment. Risk Assessment Forum, EPA/630/R-95/002B. August 1996.

USEPA. United States Environmental Protection Agency. 1995a. Region III - Biological Technical Assistance Group Screening Levels (Revised). Region III, Philadelphia, Pennsylvania. August 1995.

USEPA. United States Environmental Protection Agency. 1995b. "Toxic Substance Spreadsheet." Region IV, Water Quality Standards Section, Water Management Division. January 1995.

USEPA. United States Environmental Protection Agency. 1994. Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments. Environmental Response Team, Edison, New Jersey. Unpublished Review Draft. September 26, 1994.

USEPA. United States Environmental Protection Agency. 1993. Wildlife Exposure Factors Handbook. Office of Research and Development. Washington, D.C. EPA/600/R-93/187a. December 1993.

USEPA. United States Environmental Protection Agency. 1992a. Framework for Ecological Risk Assessment. Risk Assessment Forum. EPA/630/R-92/001. February 1992.

USEPA. United States Environmental Protection Agency. 1992b. Surface Water Quality Criteria. Federal Register. Volume 57, No. 246. December 1992.

USEPA. United States Environmental Protection Agency. 1987 United States Environmental Protection Agency. Quality Criteria for Water - 1986. Office of Water Regulations. May 1987.

VSWCB. Virginia State Water Control Board Regulations. 1992. Water Quality Standards. VR 680-21-00. May 1992.

Walkinshaw, L.H. 1953. "Life history of the prothonotary warbler." Wilson Bull. 65:152-168.

Wentsel, R., A. McIntosh, and G. Atchison. 1977. "Sublethal Effects of Heavy Metal Contaminated Sediment on Midge Larve (*Chironomous tentans*). Hydrobiologia 56(2): 153-156.

Wheelwright, N.T. 1988. "Seasonal changes in food preferences of American robins in captivity." Auk 105:374-378.

Will, M.E. and G.W. Suter II. 1995a. Toxicological Benchmarks for Potential Contaminants of Concern for Effects on Terrestrial Plants: 1995 Revision. Environmental Risk Assessment Program, Oak Ridge National Laboratory. Issued September 1995.

Will, M.E. and G.W. Suter II. 1995b. Toxicological Benchmarks for Potential Contaminants of Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Process: 1995 Revision. Environmental Risk Assessment Program, Oak Ridge National Laboratory. Issued September 1995.

Will, M.E. and G.W. Suter II. 1994a. Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Terrestrial Plants: 1994 Revision. Environmental Sciences Division, Oak Ridge National Laboratory. September 1994.

Will, M.E. and G.W. Suter II. 1994b. Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Process. Environmental Sciences Division, Oak Ridge National Laboratory. September 1994.

TABLES

TABLE 7-1

ECOLOGICAL CONTAMINANTS OF CONCERN PER MEDIA
SITES 1 AND 3
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

	Site 1	Site 3 Proper	Site 3 - Soil AOC	Sites 1 and 3		
Analyte	Surface Soil	Surface Soil	Surface Soil	Surface Water	Sediment	Groundwater
Semivolatiles						
Acenaphthene			X			
Anthracene			X			
Benzo(a)anthracene	X	X	X			
Benzo(a)pyrene	X	X	X			
Benzo(b)fluoranthene	X	X	X			
Benzo(g,h,i)perylene	X		X			
Benzo(k)fluoranthene	X		X			
Butylbenzylphthalate	X					
Carbazole			X			
Chrysene	X	X	X			
di-n-Octylphthalate						X
Dibenzo(a,h)anthracene			X			
Dibenzofuran			X			
Fluoranthene	X	X	X			
Fluorene			X			
Indeno(1,2,3-cd)pyrene	X		X			
2-Methylnaphthalene			X			
Naphthalene			X			
Phenanthrene	X	X	X			
Pyrene	X	X	X			
Nitramines						
2,4-Dinitrotoluene	X					
Inorganics						
Aluminum	X	X	X	X	X	X
Antimony		X				
Arsenic					X	X
Beryllium	X	X	X			
Cadmium					X	
Chromium	X	X	X			X
Cobalt					X	X
Copper				X		X
Cyanide		X				
Iron	X	X	X	X	X	X

TABLE 7-1 (Continued)

ECOLOGICAL CONTAMINANTS OF CONCERN PER MEDIA
SITES 1 AND 3
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

	Site 1	Site 3 Proper	Site 3 - Soil AOC	Sites 1 and 3		
Analyte	Surface Soil	Surface Soil	Surface Soil	Surface Water	Sediment	Groundwater
Inorganics (continued)						
Lead	X	X	X		X	X
Manganese		X	X	X	X	X
Mercury		X	X			
Nickel	X	X	X		X	X
Thallium		X				
Vanadium	X	X	X		X	
Zinc	X	X	X	X		X

TABLE 7-2

FREQUENCY AND RANGE OF SURFACE SOIL DATA COMPARED TO SURFACE SOIL SCREENING LEVELS
SITE 1
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Analyte	Surface Soil Screening Levels (SSSLs)[1]	Contaminant Frequency/Range		No. of Positive Detects Above SSSL	Normal 95% UCL Background Surface Soil	Ecological Contaminant of Concern ?	Reason for Exclusion
		No. of Positive Detects/No. of Samples	Range of Positive Detections				
Semivolatiles (µg/kg)							
Acenaphthylene	100	1/21	46J	0	ND	NO	Below SSSL
Anthracene	100	1/21	39J	0	ND	NO	Below SSSL
Benzo(a)anthracene	100	6/21	47J - 400	1	240J*	YES	
Benzo(a)pyrene	100	6/21	69J - 380J	1	180J*	YES	
Benzo(b)fluoranthene	100	9/21	48J - 690	5	500*	YES	
Benzo(g,h,i)perylene	100	7/21	42J - 260J	1	ND	YES	
Benzo(k)fluoranthene	100	6/21	43J - 260J	1	130J*	YES	
Bis(2-ethylhexyl)phthalate	NE	5/21	38J - 6,500	NA	ND	NO	Lab. Contaminant
Butylbenzylphthalate	NE	2/21	40J - 240J	NA	ND	YES	
Chrysene	100	7/21	56J - 480	3	270J*	YES	
Dibenzo(a,h,)anthracene	100	1/21	73J	0	ND	NO	Below SSSL
Diethylphthalate	NE	1/21	310J	NA	ND	NO	Lab. Contaminant
Fluoranthene	100	8/21	60J - 390	4	430*	YES	
Indeno(1,2,3-cd)pyrene	100	7/21	49J - 300J	1	160J*	YES	
Phenanthrene	100	1/21	200J	1	ND	YES	
Pyrene	100	8/21	52J - 470	5	320J*	YES	

TABLE 7-2 (Continued)

FREQUENCY AND RANGE OF SURFACE SOIL DATA COMPARED TO SURFACE SOIL SCREENING LEVELS
SITE 1
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Analyte	Surface Soil Screening Levels (SSSLs)[1]	Contaminant Frequency/Range		No. of Positive Detects Above SSSL	Normal 95% UCL Background Surface Soil	Ecological Contaminant of Concern ?	Reason for Exclusion
		No. of Positive Detects/No. of Samples	Range of Positive Detections				
Pesticides/PCBs(µg/kg)							
alpha-Chlordane	<100[2]	1/21	2J	0	ND	NO	Below SSSL
gamma-Chlordane	<100[2]	1/21	1.2J	0	ND	NO	Below SSSL
4,4'-DDT	<100	1/21	2J	0	ND	NO	Below SSSL
Dieldrin	<100	1/21	9.8J	0	ND	NO	Below SSSL
Aroclor-1260	100[3]	1/21	35J	0	ND	NO	Below SSSL
Nitramines (µg/kg)							
2,4-Dintrotoluene	NE	1/21	68J	NA	ND	YES	
Inorganics (mg/kg)							
Aluminum	1	21/21	1,930 - 11,200	21	14,831	YES	
Arsenic	328	21/21	0.64L - 92.5	0	6.52	NO	Below SSSL
Barium	440	21/21	6.1 - 33.6	0	26.74	NO	Below SSSL
Beryllium	0.02	15/21	0.21 - 0.55	15	0.34	YES	
Cadmium	2.5	1/21	0.47K	0	ND	NO	Below SSSL
Calcium	NE	21/21	87.6 - 2,250	NA	1,464	NO	Low Toxicity
Chromium	0.0075	21/21	3.4K - 12.4	21	19.38	YES	
Cobalt	100	17/21	0.69 - 4.2	0	2.36	NO	Below SSSL
Copper	15	21/21	1.3 - 14.6	0	4.62	NO	Below SSSL
Iron	12	21/21	2,510 - 11,700	21	23,981	YES	
Lead	0.01	21/21	2.8 - 62.3K	21	9.36	YES	

TABLE 7-2 (Continued)

FREQUENCY AND RANGE OF SURFACE SOIL DATA COMPARED TO SURFACE SOIL SCREENING LEVELS
SITE 1
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Analyte	Surface Soil Screening Levels (SSSLs)[1]	Contaminant Frequency/Range		No. of Positive Detects Above SSSL	Normal 95% UCL Background Surface Soil	Ecological Contaminant of Concern ?	Reason for Exclusion
		No. of Positive Detects/No. of Samples	Range of Positive Detections				
Inorganics (mg/kg) (continued)							
Magnesium	NE	21/21	142 - 888J	NA	1,202	NO	Low Toxicity
Manganese	330	21/21	16.8J - 126	0	65.84	NO	Below SSSL
Nickel	2	16/21	2.3K - 7.3K	16	6.65	YES	
Potassium	NE	17/21	198 - 881	NA	870	NO	Low Toxicity
Selenium	1.8	1/21	0.28L	0	0.35	NO	Below SSSL
Vanadium	0.5	21/21	5.6 - 20	21	36.65	YES	
Zinc	10	21/21	4.4K - 43.5	15	15.53	YES	

Notes:

NE Not Established
NA Not Applicable
ND Not Detected
UCL Upper Confidence Level
J Estimated value
K Value biased high
L Value biased low

* Maximum background value presented because the UCL is greater than the maximum value.
(1) USEPA Region III BTAG screening levels used, unless otherwise noted.
(2) Screening level for total chlordane
(3) Screening level for total PCBs

TABLE 7-3

FREQUENCY AND RANGE OF SURFACE SOIL DATA COMPARED TO SURFACE SOIL SCREENING LEVELS
SITE 3 PROPER
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Analyte	Surface Soil Screening Levels (SSSLs)[1]	Contaminant Frequency/Range		No. of Positive Detects Above SSSL	Normal 95% UCL Background Surface Soil	Ecological Contaminant of Concern ?	Reason for Exclusion
		No. of Positive Detects/No. of Samples	Range of Positive Detections				
Semivolatiles (µg/kg)							
Benzo(a)anthracene	100	1/15	120J	1	240J*	YES	
Benzo(a)pyrene	100	1/15	160J	1	180J*	YES	
Benzo(b)fluoranthene	100	1/15	220J	1	500*	YES	
Benzo(g,h,i)perylene	100	1/15	87J	0	ND	NO	Below SSSL
Chrysene	100	1/15	170J	1	270J*	YES	
Fluoranthene	100	1/15	140J	1	430*	YES	
Phenanthrene	100	1/15	220J	1	ND	YES	
Pyrene	100	1/15	240J	1	320J*	YES	
Pesticides/PCBs(µg/kg)							
4,4'-DDD	<100	1/15	2.4J	0	ND	NO	Below SSSL
4,4'-DDE	<100	1/15	8.5J	0	ND	NO	Below SSSL
4,4'-DDT	<100	1/15	8.9J	0	ND	NO	Below SSSL
Aroclor-1260	100[2]	2/15	25J - 31J	0	ND	NO	Below SSSL
Inorganics (mg/kg)							
Aluminum	1	15/15	985 - 11,800	15	14,831	YES	
Antimony	0.48	2/15	4.6L - 16.8L	2	ND	YES	
Arsenic	328	15/15	1.2 - 6.9	0	6.52	NO	Below SSSL
Barium	440	15/15	3.7 - 82.6	0	26.74	NO	Below SSSL
Beryllium	0.02	14/15	0.2 - 1.5	14	0.34	YES	
Cadmium	2.5	1/15	0.55L	0	ND	NO	Below SSSL
Calcium	NE	13/15	321 - 2,710	NA	1,464	NO	Low Toxicity

TABLE 7-3 (Continued)

FREQUENCY AND RANGE OF SURFACE SOIL DATA COMPARED TO SURFACE SOIL SCREENING LEVELS
SITE 3 PROPER
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Analyte	Surface Soil Screening Levels (SSSLs)[1]	Contaminant Frequency/Range		No. of Positive Detects Above SSSL	Normal 95% UCL Background Surface Soil	Ecological Contaminant of Concern ?	Reason for Exclusion
		No. of Positive Detects/No. of Samples	Range of Positive Detections				
Inorganics (mg/kg) (continued)							
Chromium	0.0075	15/15	2.9K - 31.6K	15	19.38	YES	
Cobalt	100	15/15	0.55 - 6	0	2.36	NO	Below SSSL
Copper	15	15/15	0.67 - 12.9	0	4.62	NO	Below SSSL
Cyanide	>0.005	1/15	0.89	1	ND	YES	
Iron	12	15/15	2,460 - 23,800	15	23,981	YES	
Lead	0.01	15/15	3.1 - 74.3	15	9.36	YES	
Magnesium	NE	15/15	123 - 1,050	NA	1,202	NO	Low Toxicity
Manganese	330	15/15	6.7 - 667	1	65.84	YES	
Mercury	0.058	2/15	0.05 - 0.11	1	0.03	YES	
Nickel	2	11/15	2K - 8.9	10	6.65	YES	
Potassium	NE	14/15	193L - 1,500L	NA	870	NO	Low Toxicity
Selenium	1.8	4/15	0.22 - 0.33L	0	0.35	NO	Below SSSL
Sodium	NE	13/15	4.5 - 29.1	NA	66.39	NO	Low Toxicity
Thallium	0.001	1/15	0.23K	1	ND	YES	
Vanadium	0.5	15/15	5.3 - 37.7	15	36.65	YES	
Zinc	10	13/15	3.7L - 203	12	15.53	YES	

TABLE 7-3 (Continued)

FREQUENCY AND RANGE OF SURFACE SOIL DATA COMPARED TO SURFACE SOIL SCREENING LEVELS
SITE 3 PROPER
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Notes:

NE	Not Established
NA	Not Applicable
ND	Not Detected
J	Estimated value
K	Value biased high
L	Value biased low
UCL	Upper Confidence Level
*	Maximum background value presented because the UCL is greater than the maximum value.

(1) USEPA Region III BTAG Screening level used, unless otherwise noted
(2) Screening level for total PCBs

TABLE 7-4

FREQUENCY AND RANGE OF SURFACE SOIL DATA COMPARED TO SURFACE SOIL SCREENING LEVELS
SITE 3 - SOIL AREA OF CONCERN
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Analyte	Surface Soil Screening Levels (SSSLs)[1]	Contaminant Frequency/Range		No. of Positive Detects Above SSSL	Normal 95% UCL Background Surface Soil	Ecological Contaminant of Concern ?	Reason for Exclusion
		No. of Positive Detects/No. of Samples	Range of Positive Detections				
Semivolatiles (µg/kg)							
Acenaphthene	100	4/6	260J - 18,000	4	ND	YES	
Acenaphthylene	100	1/6	60J	0	ND	NO	Below SSSL
Anthracene	100	6/6	65J - 47,000	4	ND	YES	
Benzo(a)anthracene	100	6/6	160J - 92,000	6	240J*	YES	
Benzo(a)pyrene	100	6/6	170J - 77,000	6	180J*	YES	
Benzo(b)fluoranthene	100	6/6	120J - 98,000	6	500*	YES	
Benzo(g,h,i)perylene	100	6/6	110J - 41,000	6	ND	YES	
Benzo(k)fluoranthene	100	6/6	130J - 32,000	6	130J*	YES	
Bis(2-ethylhexyl)phthalate	NE	4/6	48J-47,000	NA	ND	NO	Lab. Contaminant
Carbazole	NE	6/6	43J - 37,000	NA	ND	YES	
Chrysene	100	6/6	230J - 87,000	6	270J*	YES	
Dibenzo(a,h,)anthracene	100	5/6	41J - 12,000	4	ND	YES	
Dibenzofuran	NE	4/6	190J - 14,000	NA	ND	YES	
Fluoranthene	100	6/6	370J - 190,000	6	430*	YES	
Fluorene	100	4/6	290J - 22,000	4	ND	YES	
Indeno(1,2,3-cd)pyrene	100	6/6	120J - 147,000	6	160J*	YES	
2-Methylnaphthalene	NE	3/6	57J - 4,000J	NA	ND	YES	
Naphthalene	100	4/6	62J - 7,300J	2	ND	YES	
Phenanthrene	100	6/6	250J - 200,000	6	ND	YES	
Pyrene	100	6/6	290J - 160,000	6	320J*	YES	

TABLE 7-4 (Continued)

FREQUENCY AND RANGE OF SURFACE SOIL DATA COMPARED TO SURFACE SOIL SCREENING LEVELS
SITE 3 - SOIL AREA OF CONCERN
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Analyte	Surface Soil Screening Levels (SSSLs)[1]	Contaminant Frequency/Range		No. of Positive Detects Above SSSL	Normal 95% UCL Background Surface Soil	Ecological Contaminant of Concern ?	Reason for Exclusion
		No. of Positive Detects/No. of Samples	Range of Positive Detections				
Pesticides/PCBs (µg/kg)							
Dieldrin	<100	1/1	4.4L	0	ND	NO	Below SSSL
Endosulfan Sulfate	1,000[2]	1/1	5.3J	0	ND	NO	Below SSSL
Endrin Ketone	<100[3]	1/1	21L	0	ND	NO	Below SSSL
Methoxychlor	<100	1/1	62J	0	ND	NO	Below SSSL
Inorganics (mg/kg)							
Aluminum	1	1/1	10,100	1	14,831	YES	
Arsenic	328	1/1	9.5	0	6.52	NO	Below SSSL
Barium	440	1/1	164	0	26.74	NO	Below SSSL
Beryllium	0.02	1/1	0.98	1	0.34	YES	
Cadmium	2.5	1/1	0.74K	0	ND	NO	Below SSSL
Calcium	NE	1/1	24,000	NA	1,464	NO	Low Toxicity
Chromium	0.0075	1/1	16	1	19.38	YES	
Cobalt	100	1/1	1.2	0	2.36	NO	Below SSSL
Copper	15	1/1	10.9	0	4.62	NO	Below SSSL
Iron	12	1/1	8,040	1	23,981	YES	
Lead	0.01	1/1	59.4	1	9.36	YES	
Magnesium	NE	1/1	5,350	NA	1,202	NO	Low Toxicity
Manganese	330	1/1	1,580	1	65.84	YES	
Mercury	0.058	1/1	0.15	1	0.03	YES	
Nickel	2	1/1	21.5	1	6.65	YES	
Potassium	NE	1/1	731K	NA	870	NO	Low Toxicity
Selenium	1.8	1/1	0.58	0	0.35	NO	Below SSSL
Sodium	NE	1/1	252	NA	66.39	NO	Low Toxicity

TABLE 7-4 (Continued)

FREQUENCY AND RANGE OF SURFACE SOIL DATA COMPARED TO SURFACE SOIL SCREENING LEVELS
SITE 3 - SOIL AREA OF CONCERN
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Analyte	Surface Soil Screening Levels (SSSLs)[1]	Contaminant Frequency/Range		No. of Positive Detects Above SSSL	Normal 95% UCL Background Surface Soil	Ecological Contaminant of Concern ?	Reason for Exclusion
		No. of Positive Detects/No. of Samples	Range of Positive Detections				
Inorganics (mg/kg) (continued)							
Vanadium	0.5	1/1	142	1	36.65	YES	
Zinc	10	1/1	180	1	15.53	YES	

Notes:

NE Not Established
NA Not Applicable
ND Not Detected
J Estimated value
K Value biased high
L Value biased low
UCL Upper Confidence Level
* Maximum background value presented because the UCL is greater than the maximum value.

(1) USEPA Region III BTAG screening level used, unless otherwise noted
(2) Hulzebos et al., 1993 (EC_{50})
(3) Screening level for endrin

TABLE 7-5

FREQUENCY AND RANGE OF DETECTION OF CORNWALLIS CAVE AQUIFER GROUNDWATER DATA COMPARED TO TIDAL FRESHWATER SURFACE WATER SCREENING LEVELS SITES 1 AND 3 NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA

Analyte	Surface Water Screening Levels (SWSLs)[1]		Contaminant Frequency/Range		No. Of Positive Detects Above Lowest SWSL	Ecological Contaminant of Concern?	Reason for Exclusion
	Acute	Chronic	No. of Positive Detects/No. of Samples	Range of Positive Detections			
Volatiles (µg/L)							
Acetone	NE	NE	1/17	18	NA	NO	Laboratory Contaminant
Chloroform	NE	NE	1/17	3J	NA	NO	Laboratory Contaminant
1,1-Dichloroethene	224,000	NE	1/17	4J	0	NO	Below SWSL
1,2-Dichloroethene(total)	224,000	NE	4/17	12-570	0	NO	Below SWSL
Trichloroethene	2,000	NE	8/17	2J-860	0	NO	Below SWSL
Toluene	1,050	NE	1/17	3J	0	NO	Below SWSL/ Laboratory Contaminant
Vinyl Chloride	224,000	NE	1/17	48	0	NO	Below SWSL
Semivolatiles (µg/L)							
Di-n-octylphthalate	NE	3.4	2/17	3J-4J	1	YES	
Phenanthrene	NE	4.6	3/17	2J-2J	0	NO	Below SWSL
Phenol	5,800	NE	1/17	130	0	NO	Below SWSL
Pyrene	300	NE	1/17	2J	0	NO	Below SWSL
Total Inorganics (µg/L)							
Aluminum	NE	NE	16/17	83.8K-32,300K	NA	YES	
Arsenic	10[2]	13[2]	12/17	1.6L-24.6	7	YES	
Barium	10,000	NE	17/17	11-131	0	NO	Below SWSL
Beryllium	1,500	NE	4/17	0.99-2.3	0	NO	Below SWSL
Cadmium	4.3[3]	9.3	3/17	2.4-3.3	0	NO	Below SWSL
Calcium	NE	NE	17/17	31,300-252,000	NA	NO	Low Toxicity
Chromium	10,300[4]	50[5]	10/17	3.7-177	3	YES	

TABLE 7-5 (Continued)

FREQUENCY AND RANGE OF DETECTION OF CORNWALLIS CAVE AQUIFER GROUNDWATER DATA COMPARED TO TIDAL FRESHWATER SCREENING LEVELS
SITE 1 AND 3
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Analyte	Surface Water Screening Levels (SWSLs)[1]		Contaminant Frequency/Range		No. Of Positive Detects Above Lowest SWSL	Ecological Contaminant of Concern?	Reason for Exclusion
	Acute	Chronic	No. of Positive Detects/No. of Samples	Range of Positive Detections			
Total Inorganics (µg/L) (continued)							
Cobalt	NE	NE	9/17	3.3-13.5	NA	YES	
Copper	2.9	2.9[3]	12/17	2.7-44.2	11	YES	
Iron	NE	NE	17/17	212-91,100	NA	YES	
Lead	220[1]	5.1	12/17	0.95-26.7	6	YES	
Magnesium	NE	NE	17/17	390-14,200	NA	NO	Low Toxicity
Manganese	NE	10	16/17	3.6-621	13	YES	
Nickel	75[3]	8.3	4/17	16.3-58.6	4	YES	
Potassium	NE	NE	16/17	1,120-26,300	NA	NO	Low Toxicity
Selenium	300[3]	35	5/17	1.4L-2.7	0	NO	Below SWSL
Sodium	NE	NE	17/17	3,510-38,300	NA	NO	Low Toxicity
Vanadium	10,000	NE	14/17	2.6-225	0	NO	Below SWSL
Zinc	95[3]	19	13/17	3.6-180	8	YES	

Notes:

J Estimated value
K Value biased high
L Value biased low

(1) USEPA Region III BTAG screening levels used, unless otherwise noted
(2) Arsenic V screening level
(3) USEPA, 1992 and VSWCB, 1992
(4) Chromium III screening level
(5) Chromium VI screening level

TABLE 7-6

FREQUENCY AND RANGE OF SURFACE WATER DATA COMPARED TO TIDAL FRESHWATER SCREENING LEVELS
SITE 1 AND 3
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Analyte	Surface Water Screening Levels (SWSLs)[1]		Contaminant Frequency/Range		No of Positive Detects Above Lowest SWSL	Normal 95% UCL Tidal Freshwater Background	Ecological Contaminant of Concern?	Reason for Exclusion
	Acute	Chronic	No. of Positive Detects/No. of Samples	Range of Positive Detections				
Inorganics (µg/L)								
Aluminum	NE	NE	4/4	1,110 - 2,420	NA	2,677	YES	
Barium	10,000	NE	4/4	31 - 32	0	41.37	NO	Below SWSL
Cadmium	43[2]	9.3	4/4	7.8L - 9.1L	0	3.83	NO	Below SWSL
Calcium	NE	NE	4/4	194,000J - 249,000J	NA	139,236	NO	Low Toxicity
Copper	2.9	2.9[2]	4/4	7.4K - 9.1K	4	4.01	YES	
Iron	NE	NE	4/4	1,220J - 3,250J	NA	3,983	YES	
Lead	220[2]	5.1	2/4	1.8L - 2.4L	0	2.29	NO	Below SWSL
Magnesium	NE	NE	4/4	598,000 - 786,000	NA	431,151	NO	Low Toxicity
Manganese	NE	10	4/4	20.8 - 54.9J	47	254	YES	
Potassium	NE	NE	4/4	193,000 - 249,000	NA	142,664	NO	Low Toxicity
Sodium	NE	NE	4/4	4,680,000 - 6,040,000	NA	3,883,074	NO	Low Toxicity
Vanadium	10,000	NE	4/4	9.7 - 13.4	0	8.85	NO	Below SWSL
Zinc	95[2]	19	4/4	10.4K - 20.1K	1	10.95	YES	

Notes:

NE Not Established
NA Not Applicable
J Estimated value
K Value biased high
L Value biased low
UCL Upper confidence level

(1) USEPA Region III BTAG screening levels used, unless otherwise noted
(2) USEPA, 1992b and VSWCB, 1992

TABLE 7-7

FREQUENCY AND RANGE OF SEDIMENT DATA COMPARED TO SEDIMENT SCREENING LEVELS
SITES 1 AND 3
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Analyte	Sediment Screening Levels (SSLs)[1]		Contaminant Frequency/Range		No. of Positive Detects Above Lowest SSL	Normal 95% UCL Tidal Freshwater Stream Background	Ecological Contaminant of Concern ?	Reason for Exclusion
	BSLs/ ER-Ls	ER-Ms[2]	No. of Positive Detects/ No. of Samples	Range of Positive Detections				
Volatiles (µg/kg)								
Acetone	NE	NE	4/10	66 - 230	NA	243	NO	Lab. Contaminant
Carbon Disulfide	NE	NE	3/10	10J - 29	NA	29.84	NO	Lab. Contaminant
Toluene	NE	NE	1/10	2J	NA	ND	NO	Lab. Contaminant
Inorganics (mg/kg)								
Aluminum	NE	NE	10/10	434 - 21,100	NA	23,398	YES	
Arsenic	8.2	70	8/10	0.63 - 15.4J	4	8.70	YES	
Barium	NE	500[3]	10/10	1.9J - 46.1J	0	54.26	NO	Below SSL
Cadmium	1.2	9.6	1/10	1.7	1	ND	YES	
Calcium	NE	NE	10/10	341J - 129,000J	NA	2,540	NO	Low Toxicity
Chromium	81	370	9/10	1.1 - 45.8	0	44.49	NO	Below SSL
Cobalt	NE	NE	7/10	0.46 - 8.9	NA	9.86	YES	
Copper	34	270	10/10	0.82 - 26.7	0	22.26	NO	Below SSL
Iron	NE	27,000[4]	10/10	577 - 39,100	6	34,425	YES	
Lead	46.7	218	10/10	0.91 - 56.8	1	29.34	YES	
Magnesium	NE	NE	10/10	60.8 - 9,050	NA	6,485	NO	Low Toxicity
Manganese	NE	230[4]	10/10	3.7 - 379	4	532	YES	
Nickel	20.9	51.6	6/10	11.8 - 21	1	28.02	YES	
Potassium	NE	NE	7/10	141 - 5,090	NA	4,208	NO	Low Toxicity
Sodium	NE	NE	8/10	318 - 21,100	NA	9,128	NO	Low Toxicity

TABLE 7-7 (Continued)

FREQUENCY AND RANGE OF SEDIMENT DATA COMPARED TO SEDIMENT SCREENING LEVELS
SITES 1 AND 3
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Analyte	Sediment Screening Levels (SSLs)[1]		Contaminant Frequency/Range		No. of Positive Detects Above Lowest SSL	Normal 95% UCL Tidal Freshwater Stream Background	Ecological Contaminant of Concern ?	Reason for Exclusion
	BSLs/ ER-Ls	ER-Ms[2]	No. of Positive Detects/ No. of Samples	Range of Positive Detections				
Inorganics (Continued)								
Vanadium	NE	NE	10/10	0.79 - 51.8	NA	51.30	YES	
Zinc	150	410	10/10	3.1 - 135	0	116	NO	Below SSL

Notes:

BSL United States Environmental Protection Agency, Region III, Biological Technical Assistance Group Screening Level
ER-L Effects Range-Low
ER-M Effects Range-Median
NE Not Established
NA Not Applicable
ND Not Detected
J Estimated value
UCL Upper Confidence Level

(1) USEPA Region III BTAG screening levels used, unless otherwise noted
(2) Long et al., 1995
(3) Sullivan et al., 1985
(4) Tetra Tech, Inc., 1986 (apparent effects threshold)

TABLE 7-8

RECEPTOR MODEL INPUT PARAMETERS
SITES 1 AND 3
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Species	Model Inputs				
	Conservatism of Inputs	Body Weight (kg)	Food Ingestion (kg/day)	Soil/Sediment Ingestion (kg/day)	Water Ingestion (L/day)
Largemouth Bass	Conv.	1.1[1]	0.133[2]	NA	NA
	Less Conv.	NA	NA	NA	NA
Great Blue Heron	Conv.	2.229[3] (lowest value)	0.6[4]	0.054[10]	0.12[6]
	Less Conv.	2.268[6] (average value)	0.408[5]	0.036[6]	0.102[6]
Bull Frog	Conv.	0.142[7] (lowest value)	1.01×10^{-02}[6]	5.98×10^{-04}[8]	NA
	Less Conv.	0.196[7] (average value)	9.94×10^{-03}[6]	5.87×10^{-04}[10]	NA
American Woodcock	Conv.	0.165[11]	0.083[11]	7.5×10^{-03}[10]	0.017[6]
	Less Conv.	0.169[9]	0.130[6]	0.014[10]	0.017[6]
Red-tailed Hawk	Conv.	0.957[12] (lowest value)	0.4[8]	0.003[13]	0.056[13]
	Less Conv.	1.134[6] (average value)	0.112[6]	0.003[13]	0.065[6]
American Robin	Conv.	0.077[14]	0.118[6]	0.035[10]	0.011[6]
	Less Conv.	0.081[15]	0.098[6]	0.029[10]	0.011[6]
Marsh Wren	Conv.	0.010[16]	9.06×10^{-03}[6]	9.43×10^{-04}[6]	2.8×10^{-03}[6]
	Less Conv.	0.0161[17]	3.6×10^{-03}[17]	9.43×10^{-04}[6]	4.0×10^{-03}[18]
Red Fox	Conv.	4.53[19]	0.590[20]	1.65×10^{-02}[10]	0.385[6]
	Less Conv.	5[21]	0.32[21]	9.0×10^{-03}[10]	0.275[13]
Short-Tailed Shrew	Conv.	0.015[22] (lowest value)	0.009[6]	9.67×10^{-04}[10]	0.003[6]
	Less Conv.	0.017[23] (average value)	0.009[6]	9.67×10^{-04}[10]	0.004[6]
Meadow Vole	Conv.	0.017[6] (lowest value)	0.006[6]	1.43×10^{-04}[10]	0.004[6]
	Less Conv.	0.033[24] (average value)	0.011[6]	2.56×10^{-04}[10]	0.006[6]

TABLE 7-8 (continued)

RECEPTOR MODEL INPUT PARAMETERS
SITES 1 AND 3
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Species	Model Inputs				
	Conservatism of Inputs	Body Weight (kg)	Food Ingestion (kg/day)	Soil/Sediment Ingestion (kg/day)	Water Ingestion (L/day)
Deer Mouse	Conv.	0.015[25]	2.9×10^{-03}[26]	7.0×10^{-05}[10]	1.9×10^{-03}[13]
	Less Conv.	0.019[22]	3.8×10^{-03}[27]	7.55×10^{-05}[10]	3.68×10^{-03}[6]

Notes:

NA Not Available
Conv. Conservative
kg kilogram
L liter

(1) Pflieger, 1975
(2) NRC, 1993
(3) Quinney, 1982
(4) Newell et al., 1987
(5) Kushlan (unpublished)
(6) USEPA, 1993
(7) McAlpine and Dilworth, 1989
(8) Kirkwood, 1980
(9) Marshall (unpublished)
(10) Beyer, 1994
(11) Ehrlich et al, 1988; Sheldon, 1967
(12) Steenhof, 1983
(13) BTAG life history information
(14) Clench and Leberman, 1978
(15) Wheelwright, 1986
(16) Tintle (unpublished)
(17) Walkinshaw, 1953
(18) Calder and Braun, 1983
(19) Storm et al., 1976
(20) Sargeant, 1978
(21) Samuel and Nelson, 1982
(22) Schlesinger and Potter, 1974
(23) Guilday, 1957
(24) Myers and Krebs, 1971
(25) Burt and Grossenheider, 1980
(26) Cronin and Bradley, 1988
(27) Millar and Innes, 1983

TABLE 7-9

LOWEST OBSERVED ADVERSE EFFECT LEVELS AND NO OBSERVED ADVERSE EFFECT LEVELS
SITE 1 -TERRESTRIAL SPECIES
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Ecological Contaminant of Concern	Vole		Shrew		Robin		Hawk		Woodcock		Wren		Red Fox		Deer Mouse	
	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL
Benzo(a)anthracene	2.6	1.3	2.6	1.3	100	10	100	10	100	10	100	10	2.6	1.3	2.6	1.3
Benzo(a)pyrene	2.6	1.3	2.6	1.3	100	10	100	10	100	10	100	10	2.6	1.3	2.6	1.3
Benzo(b)fluoranthene	2.6	1.3	2.6	1.3	100	10	100	10	100	10	100	10	2.6	1.3	2.6	1.3
Benzo(g,h,i)perylene	2.6	1.3	2.6	1.3	100	10	100	10	100	10	100	10	2.6	1.3	2.6	1.3
Benzo(k)fluoranthene	2.6	1.3	2.6	1.3	100	10	100	10	100	10	100	10	2.6	1.3	2.6	1.3
Butylbenzylphthalate	1590	159	1590	159	NA	NA	NA	NA	NA	NA	NA	NA	1590	159	1590	159
Chrysene	2.6	1.3	2.6	1.3	100	10	100	10	100	10	100	10	2.6	1.3	2.6	1.3
Fluoranthene	2.6	1.3	2.6	1.3	100	10	100	10	100	10	100	10	2.6	1.3	2.6	1.3
Indeno(1,2,3-cd)pyrene	2.6	1.3	2.6	1.3	100	10	100	10	100	10	100	10	2.6	1.3	2.6	1.3
Phenanthrene	2.6	1.3	2.6	1.3	100	10	100	10	100	10	100	10	2.6	1.3	2.6	1.3
Pyrene	2.6	1.3	2.6	1.3	100	10	100	10	100	10	100	10	2.6	1.3	2.6	1.3
Dinitrotoluene, 2,4-	1.5	0.2	1.5	0.2	NA	NA	NA	NA	NA	NA	NA	NA	1.5	0.2	1.5	0.2
Aluminum	19.3	1.93	19.3	1.93	1097	109.7	1097	109.7	1097	109.7	1097	109.7	19.3	1.93	19.3	1.93
Beryllium	5.4	0.54	5.4	0.54	NA	NA	NA	NA	NA	NA	NA	NA	5.4	0.54	5.4	0.54
Chromium	0.25	0.025	0.25	0.025	1	0.1	1	0.1	10	0.1	10	0.1	0.25	0.025	0.25	0.025
Copper	10	1	10	1	2.35	0.235	2.35	0.235	2.35	0.235	2.35	0.235	10	1	10	1
Iron	500	50	500	50	1000	100	1000	100	1000	100	1000	100	500	50	500	50
Lead	1.5	0.15	1.5	0.15	3	0.3	3	0.3	3	0.3	3	0.3	1.5	0.15	1.5	0.15
Manganese	880	88	880	88	9970	997	9970	997	9970	997	9970	997	880	88	880	88
Nickel	625	62.5	625	62.5	NA	NA	NA	NA	NA	NA	NA	NA	625	62.5	625	62.5
Vanadium	2	0.2	2	0.2	113.8	11.38	113.8	11.38	113.8	11.38	113.8	11.38	2	0.2	2	0.2
Zinc	250	25	250	25	139	13.9	139	13.9	139	13.9	139	13.9	250	25	250	25

NA - Not Available
LOAEL - Lowest Observed Adverse Effects Level
NOAEL - No Observed Adverse Effects Level

TABLE 7-10

LOWEST OBSERVED ADVERSE EFFECT LEVELS AND NO OBSERVED ADVERSE EFFECT LEVELS
SITE 3 -TERRESTRIAL SPECIES
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Ecological Contaminant of Concern	Woodcock		Hawk		Robin		Wren		Red Fox		Shrew		Vole		Deer Mouse	
	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL
Acenaphthene	100	10	100	10	100	10	100	10	2.6	1.3	2.6	1.3	2.6	1.3	2.6	1.3
Anthracene	100	10	100	10	100	10	100	10	2.6	1.3	2.6	1.3	2.6	1.3	2.6	1.3
Benzo(a)anthracene	100	10	100	10	100	10	100	10	2.6	1.3	2.6	1.3	2.6	1.3	2.6	1.3
Benzo(a)pyrene	100	10	100	10	100	10	100	10	2.6	1.3	2.6	1.3	2.6	1.3	2.6	1.3
Benzo(b)fluoranthene	100	10	100	10	100	10	100	10	2.6	1.3	2.6	1.3	2.6	1.3	2.6	1.3
Benzo(g,h,i)perylene	100	10	100	10	100	10	100	10	2.6	1.3	2.6	1.3	2.6	1.3	2.6	1.3
Benzo(k)fluoranthene	100	10	100	10	100	10	100	10	2.6	1.3	2.6	1.3	2.6	1.3	2.6	1.3
Carbazole	100	10	100	10	100	10	100	10	2.6	1.3	2.6	1.3	2.6	1.3	2.6	1.3
Chrysene	100	10	100	10	100	10	100	10	2.6	1.3	2.6	1.3	2.6	1.3	2.6	1.3
Dibenz(a,h)anthracene	100	10	100	10	100	10	100	10	2.6	1.3	2.6	1.3	2.6	1.3	2.6	1.3
Dibenzofuran	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Fluoranthene	100	10	100	10	100	10	100	10	2.6	1.3	2.6	1.3	2.6	1.3	2.6	1.3
Fluorene	100	10	100	10	100	10	100	10	2.6	1.3	2.6	1.3	2.6	1.3	2.6	1.3
Indeno(1,2,3-cd)pyrene	100	10	100	10	100	10	100	10	2.6	1.3	2.6	1.3	2.6	1.3	2.6	1.3
Methylnaphthalene, 2-	100	10	100	10	100	10	100	10	2.6	1.3	2.6	1.3	2.6	1.3	2.6	1.3
Naphthalene	100	10	100	10	100	10	100	10	2.6	1.3	2.6	1.3	2.6	1.3	2.6	1.3
Phenanthrene	100	10	100	10	100	10	100	10	2.6	1.3	2.6	1.3	2.6	1.3	2.6	1.3
Pyrene	100	10	100	10	100	10	100	10	2.6	1.3	2.6	1.3	2.6	1.3	2.6	1.3
Dinitrotoluene, 2,4-	NA	NA	NA	NA	NA	NA	NA	NA	1.5	0.2	1.5	0.2	1.5	0.2	1.5	0.2
Aluminum	1097	109.7	1097	109.7	1097	109.7	1097	109.7	19.3	1.93	19.3	1.93	19.3	1.93	19.3	1.93
Antimony	NA	NA	NA	NA	NA	NA	NA	NA	0.35	0.035	0.35	0.035	0.35	0.035	0.35	0.035
Arsenic	3.3	0.33	3.3	0.33	3.3	0.33	3.3	0.33	1.5	0.15	1.5	0.15	1.5	0.15	1.5	0.15
Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	5.4	0.54	5.4	0.54	5.4	0.54	5.4	0.54
Chromium	10	0.1	1	0.1	1	0.1	10	0.1	0.25	0.025	0.25	0.025	0.25	0.025	0.25	0.025
Copper	2.35	0.235	2.35	0.235	2.35	0.235	2.35	0.235	10	1	10	1	10	1	10	1
Cyanide	45	4.5	45	4.5	45	4.5	45	4.5	8	0.8	8	0.8	8	0.8	8	0.8
Iron	1000	100	1000	100	1000	100	1000	100	500	50	500	50	500	50	500	50
Lead	3	0.3	3	0.3	3	0.3	3	0.3	1.5	0.15	1.5	0.15	1.5	0.15	1.5	0.15
Manganese	9970	997	9970	997	9970	997	9970	997	880	88	880	88	880	88	880	88
Mercury	0.12	0.012	0.1	0.01	0.1	0.01	0.12	0.012	0.1	0.01	0.5	0.05	0.5	0.05	0.5	0.05
Nickel	NA	NA	NA	NA	NA	NA	NA	NA	625	62.5	625	62.5	625	62.5	625	62.5
Thallium	NA	NA	NA	NA	NA	NA	NA	NA	0.74	0.23	0.74	0.23	0.74	0.23	0.74	0.23
Vanadium	113.8	11.38	113.8	11.38	113.8	11.38	113.8	11.38	2	0.2	2	0.2	2	0.2	2	0.2
Zinc	139	13.9	139	13.9	139	13.9	139	13.9	250	25	250	25	250	25	250	25

NA - Not Available
LOAEL - Lowest Observed Adverse Effects Level
NOAEL - No Observed Adverse Effects Level

TABLE 7-11

LOWEST OBSERVED ADVERSE EFFECT LEVELS AND NO OBSERVED ADVERSE EFFECT LEVELS
SITES 1 AND 3 - AQUATIC SPECIES
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Ecological Contaminant of Concern	Frog		Heron		Bass	
	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL
Aluminum	NA	NA	1097	109.7	NA	NA
Arsenic	NA	NA	3.3	0.33	NA	NA
Cadmium	NA	NA	3.31	0.331	NA	NA
Cobalt	NA	NA	10	1	NA	NA
Copper	NA	NA	2.35	0.235	NA	NA
Iron	NA	NA	1000	100	NA	NA
Lead	NA	NA	3	0.3	NA	NA
Manganese	NA	NA	9970	997	NA	NA
Nickel	NA	NA	NA	NA	NA	NA
Vanadium	NA	NA	113.8	11.38	NA	NA
Zinc	370	37	139	13.9	NA	NA

NA - Not Available
LOAEL - Lowest Observed Adverse Effects Level
NOAEL - No Observed Adverse Effects Level

TABLE 7-12

COMPARISON OF FLORA AND FAUNA BENCHMARK VALUES TO SURFACE SOIL CONCENTRATIONS
SITE 1
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Ecological Contaminant of Concern	Maximum Concentration	No. of Positive Detects/ No. of Samples	Flora			Fauna			Normal 95% UCL Background Surface Soil
			Benchmark	Reference	HQ	Benchmark	Reference	HQ	
Semivolatiles (µg/kg)									
Benzo(a)anthracene	400	6/21	NE	NA	NA	NE	NA	NA	240J*
Benzo(a)pyrene	380J	6/21	NE	NA	NA	25,000	a-invertebrate	0.02	180J*
Benzo(b)fluoranthene	690	9/21	NE	NA	NA	NE	NA	NA	500*
Benzo(g,h,i)perylene	260J	7/21	NE	NA	NA	NE	NA	NA	ND
Benzo(k)fluoranthene	260J	6/21	NE	NA	NA	NE	NA	NA	130J*
Butylbenzylphthalate	240J	2/21	NE	NA	NA	NE	NA	NA	ND
Chrysene	480	7/21	NE	NA	NA	NE	NA	NA	270J*
Fluoranthene	390	8/21	NE	NA	NA	NE	NA	NA	430*
Indeno(1,2,3-cd)pyrene	300J	7/21	NE	NA	NA	NE	NA	NA	160J*
Phenanthrene	200J	1/21	NE	NA	NA	99,900	b-browner earthworm	0.002	ND
Pyrene	470	8/21	NE	NA	NA	NE	NA	NA	320J*
Nitramines (µg/kg)									
2,4-Dintrotoluene	68J	1/21	NE	NA	NA	NE	NA	NA	ND
Inorganics (mg/kg)									
Aluminum	11,200	21/21	50	a-plants	224.0	600	a-microorg.	18.67	14,831
Beryllium	0.55	15/21	10	a-plants	0.06	NE	NA	NA	0.34
Chromium	12.4	21/21	1	a-plants	12.40	0.15	a-earthworm	82.67	19.38
Iron	11,700	21/21	NE	NA	NA	200	a-microorg.	58.50	23,981
Lead	62.3K	21/21	50	a-plants	1.25	500	a-earthworm	8.03	9.36
Nickel	7.3K	16/21	30	a-plants	0.24	90	a-microorg.	0.08	6.65

TABLE 7-12 (Continued)

COMPARISON OF FLORA AND FAUNA BENCHMARK VALUES TO SURFACE SOIL CONCENTRATIONS
SITE 1
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Ecological Contaminant of Concern	Maximum Concentration	No. of Positive Detects/ No. of Samples	Flora			Fauna			Normal 95% UCL Background Surface Soil
			Benchmark	Reference	HQ	Benchmark	Reference	HQ	
Vanadium	20	21/21	2	a-plants	10.00	20	a-microorg.	1.00	36.65
Zinc	43.5	21/21	50	a-plants	0.87	100	a-microorg.	0.44	15.53

Notes:

Highlighted areas represent hazard quotients greater than one.
* Maximum background value presented because the UCL is greater than the maximum value.

a - Will and Suter, 1995a/b
b - Browner et al., 1993

HQ Hazard Quotient (equivalent to benchmark divided by maximum concentration)
NE Not Established
NA Not Applicable
ND Not Detected
J Analyte was positively identified, value is estimated
K Estimated value, biased high
UCL Upper Confidence Level

TABLE 7-13

TERRESTRIAL SPECIES - CONSERVATIVE INPUTS
MAXIMUM CONCENTRATION HAZARD QUOTIENT VALUES
SITE 1
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Ecological Contaminant of Concern	Vole		Shrew		Robin		Hawk		Woodcock		Wren		Fox		Mouse	
	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l
Benzo(a)anthracene	1.10E-01	5.51E-02	2.11E-01	1.05E-01	7.90E-02	7.90E-03	1.68E-02	1.68E-03	2.19E-02	2.19E-03	3.86E-02	3.86E-03	4.12E-02	2.06E-02	5.99E-02	2.99E-02
Benzo(a)pyrene	1.05E-01	5.24E-02	2.00E-01	1.00E-01	7.51E-02	7.51E-03	1.60E-02	1.60E-03	2.08E-02	2.08E-03	3.66E-02	3.66E-03	3.91E-02	1.96E-02	5.69E-02	2.85E-02
Benzo(b)fluoranthene	1.90E-01	9.51E-02	3.63E-01	1.82E-01	1.36E-01	1.36E-02	2.90E-02	2.90E-03	3.78E-02	3.78E-03	6.65E-02	6.65E-03	7.10E-02	3.55E-02	1.03E-01	5.17E-02
Benzo(g,h,i)perylene	7.17E-02	3.58E-02	1.37E-01	6.84E-02	5.14E-02	5.14E-03	1.09E-02	1.09E-03	1.43E-02	1.43E-03	2.51E-02	2.51E-03	2.68E-02	1.34E-02	3.89E-02	1.95E-02
Benzo(k)fluoranthene	7.17E-02	3.58E-02	1.37E-01	6.84E-02	5.14E-02	5.14E-03	1.09E-02	1.09E-03	1.43E-02	1.43E-03	2.51E-02	2.51E-03	2.68E-02	1.34E-02	3.89E-02	1.95E-02
Butylbenzylphthalate	5.41E-04	5.41E-05	1.03E-03	1.03E-04	NA	NA	NA	NA	NA	NA	NA	NA	2.02E-04	2.02E-05	2.94E-04	2.94E-05
Chrysene	1.32E-01	6.62E-02	2.53E-01	1.26E-01	9.49E-02	9.49E-03	2.02E-02	2.02E-03	2.63E-02	2.63E-03	4.63E-02	4.63E-03	4.94E-02	2.47E-02	7.19E-02	3.59E-02
Fluoranthene	1.08E-01	5.38E-02	2.05E-01	1.03E-01	7.71E-02	7.71E-03	1.64E-02	1.64E-03	2.14E-02	2.14E-03	3.76E-02	3.76E-03	4.01E-02	2.01E-02	5.84E-02	2.92E-02
Indeno(1,2,3-cd)pyrene	8.27E-02	4.14E-02	1.58E-01	7.90E-02	5.93E-02	5.93E-03	1.26E-02	1.26E-03	1.65E-02	1.65E-03	2.89E-02	2.89E-03	3.09E-02	1.54E-02	4.49E-02	2.25E-02
Phenanthrene	5.51E-02	2.76E-02	1.05E-01	5.27E-02	3.95E-02	3.95E-03	8.42E-03	8.42E-04	1.10E-02	1.10E-03	1.93E-02	1.93E-03	2.06E-02	1.03E-02	2.99E-02	1.50E-02
Pyrene	1.30E-01	6.48E-02	2.47E-01	1.24E-01	9.29E-02	9.29E-03	1.98E-02	1.98E-03	2.58E-02	2.58E-03	4.53E-02	4.53E-03	4.84E-02	2.42E-02	7.04E-02	3.52E-02
Dinitrotoluene, 2,4-	1.22E-01	1.62E-02	2.33E-01	3.10E-02	NA	NA	NA	NA	NA	NA	NA	NA	4.55E-02	6.07E-03	6.62E-02	8.82E-03
Aluminum	2.08E+03	2.08E+02	3.97E+03	3.97E+02	2.02E+02	2.02E+01	4.30E+01	4.30E+00	5.60E+01	5.60E+00	9.84E+01	9.84E+00	7.76E+02	7.76E+01	1.13E+03	1.13E+02
Beryllium	3.65E-01	3.65E-02	6.97E-01	6.97E-02	NA	NA	NA	NA	NA	NA	NA	NA	1.36E-01	1.36E-02	1.98E-01	1.98E-02
Chromium	1.78E+02	1.78E+01	3.40E+02	3.40E+01	2.45E+02	2.45E+01	5.22E+01	5.22E+00	6.80E+01	6.80E+01	1.20E+02	1.20E+00	6.64E+01	6.64E+00	9.66E+01	9.66E+00
Copper	5.23E+00	5.23E-01	1.00E+01	1.00E+00	1.23E+02	1.23E+01	2.62E+01	2.62E+00	3.41E+01	3.41E+00	5.99E+01	5.99E+00	1.95E+00	1.95E-01	2.84E+00	2.84E-01
Iron	8.39E+01	8.39E+00	1.60E+02	1.60E+01	2.31E+02	2.31E+01	4.92E+01	4.92E+00	6.42E+01	6.42E+00	1.13E+02	1.13E+01	3.13E+01	3.13E+00	4.56E+01	4.56E+00
Lead	1.49E+02	1.49E+01	2.84E+02	2.84E+01	4.10E+02	4.10E+01	8.74E+01	8.74E+00	1.14E+02	1.14E+01	2.00E+02	2.00E+01	5.56E+01	5.56E+00	8.09E+01	8.09E+00
Manganese	5.13E-01	5.13E-02	9.80E-01	9.80E-02	2.50E-01	2.50E-02	5.32E-02	5.32E-03	6.93E-02	6.93E-03	1.22E-01	1.22E-02	1.92E-01	1.92E-02	2.79E-01	2.79E-02
Nickel	4.19E-02	4.19E-03	7.99E-02	7.99E-03	NA	NA	NA	NA	NA	NA	NA	NA	1.56E-02	1.56E-03	2.27E-02	2.27E-03
Vanadium	3.59E+01	3.59E+00	6.85E+01	6.85E+00	3.47E+00	3.47E-01	7.40E-01	7.40E-02	9.64E-01	9.64E-02	1.69E+00	1.69E-01	1.34E+01	1.34E+00	1.95E+01	1.95E+00
Zinc	6.24E-01	6.24E-02	1.19E+00	1.19E-01	6.18E+00	6.18E-01	1.32E+00	1.32E-01	1.72E+00	1.72E-01	3.02E+00	3.02E-01	2.33E-01	2.33E-02	3.39E-01	4.13E-02

NA - Not Available

TABLE 7-14

TERRESTRIAL SPECIES - CONSERVATIVE INPUTS
MEAN CONCENTRATION HAZARD QUOTIENT VALUES
SITE 1
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

	Vole		Shrew		Robin		Hawk		Woodcock		Wren		Fox		Mouse	
Ecological Contaminant of Concern	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l
Benzo(a)anthracene	4.71E-02	2.35E-02	8.99E-02	4.50E-02	3.38E-02	3.38E-03	7.19E-03	7.19E-04	9.37E-03	9.37E-04	1.65E-02	1.65E-03	1.76E-02	8.79E-03	2.56E-02	1.28E-02
Benzo(a)pyrene	4.70E-02	2.35E-02	8.98E-02	4.49E-02	3.37E-02	3.37E-03	7.18E-03	7.18E-04	9.35E-03	9.35E-04	1.64E-02	1.64E-03	1.75E-02	8.77E-03	2.55E-02	1.28E-02
Benzo(b)fluoranthene	5.06E-02	2.53E-02	9.66E-02	4.83E-02	3.62E-02	3.62E-03	7.72E-03	7.72E-04	1.01E-02	1.01E-03	1.77E-02	1.77E-03	1.89E-02	9.44E-03	2.75E-02	1.37E-02
Benzo(g,h,i)perylene	4.29E-02	2.15E-02	8.20E-02	4.10E-02	3.08E-02	3.08E-03	6.56E-03	6.56E-04	8.54E-03	8.54E-04	1.50E-02	1.50E-03	1.60E-02	8.01E-03	2.33E-02	1.17E-02
Benzo(k)fluoranthene	4.47E-02	2.24E-02	8.54E-02	4.27E-02	3.21E-02	3.21E-03	6.83E-03	6.83E-04	8.90E-03	8.90E-04	1.56E-02	1.56E-03	1.67E-02	8.35E-03	2.43E-02	1.22E-02
Butylbenzylphthalate	4.16E-04	4.16E-05	7.95E-04	7.95E-05	NA	NA	NA	NA	NA	NA	NA	NA	1.55E-04	1.55E-05	2.26E-04	2.26E-05
Chrysene	4.81E-02	2.41E-02	9.19E-02	4.60E-02	3.45E-02	3.45E-03	7.35E-03	7.35E-04	9.57E-03	9.57E-04	1.68E-02	1.68E-03	1.80E-02	8.98E-03	2.61E-02	1.31E-02
Fluoranthene	4.88E-02	2.44E-02	9.31E-02	4.66E-02	3.49E-02	3.49E-03	7.44E-03	7.44E-04	9.70E-03	9.70E-04	1.71E-02	1.71E-03	1.82E-02	9.10E-03	2.65E-02	1.32E-02
Indeno(1,2,3-cd)pyrene	4.44E-02	2.22E-02	8.48E-02	4.24E-02	3.18E-02	3.18E-03	6.78E-03	6.78E-04	8.84E-03	8.84E-04	1.55E-02	1.55E-03	1.66E-02	8.29E-03	2.41E-02	1.21E-02
Phenanthrene	5.24E-02	2.62E-02	1.00E-01	5.00E-02	3.75E-02	3.75E-03	8.00E-03	8.00E-04	1.04E-02	1.04E-03	1.83E-02	1.83E-03	1.96E-02	9.78E-03	2.85E-02	1.42E-02
Pyrene	4.94E-02	2.47E-02	9.43E-02	4.72E-02	3.54E-02	3.54E-03	7.54E-03	7.54E-04	9.82E-03	9.82E-04	1.73E-02	1.73E-03	1.84E-02	9.22E-03	2.68E-02	1.34E-02
Dinitrotoluene, 2,4-	3.29E-01	4.39E-02	6.29E-01	8.38E-02	NA	NA	NA	NA	NA	NA	NA	NA	1.23E-01	1.64E-02	1.79E-01	2.38E-02
Aluminum	9.07E+02	9.07E+01	1.73E+03	1.73E+02	8.79E+01	8.79E+00	1.87E+01	1.87E+00	2.44E+01	2.44E+00	4.29E+01	4.29E+00	3.38E+02	3.38E+01	4.93E+02	4.93E+01
Beryllium	1.66E-01	1.66E-02	3.17E-01	3.17E-02	NA	NA	NA	NA	NA	NA	NA	NA	6.19E-02	6.19E-03	9.01E-02	9.01E-03
Chromium	9.32E+01	9.32E+00	1.78E+02	1.78E+01	1.28E+02	1.28E+01	2.74E+01	2.74E+00	3.57E+01	3.57E-01	6.27E+01	6.27E-01	3.48E+01	3.48E+00	5.06E+01	5.06E+00
Copper	1.28E+00	1.28E-01	2.45E+00	2.45E-01	3.01E+01	3.01E+00	6.41E+00	6.41E-01	8.36E+00	8.36E-01	1.47E+01	1.47E+00	4.80E-01	4.80E-02	6.98E-01	6.98E-02
Iron	3.98E+01	3.98E+00	7.59E+01	7.59E+00	1.10E+02	1.10E+01	2.33E+01	2.33E+00	3.04E+01	3.04E+00	5.35E+01	5.35E+00	1.48E+01	1.48E+00	2.16E+01	2.16E+00
Lead	2.30E+01	2.30E+00	4.39E+01	4.39E+00	6.34E+01	6.34E+00	1.35E+01	1.35E+00	1.76E+01	1.76E+00	3.09E+01	3.09E+00	8.58E+00	8.58E-01	1.25E+01	1.25E+00
Manganese	2.17E-01	2.17E-02	4.14E-01	4.14E-02	1.06E-01	1.06E-02	2.25E-02	2.25E-03	2.93E-02	2.93E-03	5.15E-02	5.15E-03	8.10E-02	8.10E-03	1.18E-01	1.18E-02
Nickel	1.97E-02	1.97E-03	3.76E-02	3.76E-03	NA	NA	NA	NA	NA	NA	NA	NA	7.34E-03	7.34E-04	1.07E-02	1.07E-03
Vanadium	1.81E+01	1.81E+00	3.46E+01	3.46E+00	1.75E+00	1.75E-01	3.74E-01	3.74E-02	4.87E-01	4.87E-02	8.56E-01	8.56E-02	6.76E+00	6.76E-01	9.84E+00	9.84E-01
Zinc	2.28E-01	2.28E-02	4.35E-01	4.35E-02	2.26E+00	2.26E-01	4.82E-01	4.82E-02	6.28E-01	6.28E-02	1.10E+00	1.10E-01	8.51E-02	8.51E-03	1.24E-01	1.51E-02

NA - Not Available

TABLE 7-15

TERRESTRIAL SPECIES - LESS CONSERVATIVE INPUTS
MAXIMUM CONCENTRATION HAZARD QUOTIENT VALUES
SITE 1
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Ecological Contaminants of Concern	Vole		Shrew		Robin		Hawk		Woodcock		Wren		Fox		Mouse	
	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l
Benzo(a)anthracene	1.02E-01	5.12E-02	1.88E-01	9.42E-02	6.27E-02	6.27E-03	4.06E-03	4.06E-04	3.40E-02	3.40E-03	8.94E-02	8.94E-03	2.02E-02	1.01E-02	6.12E-02	3.06E-02
Benzo(a)pyrene	9.73E-02	4.86E-02	1.79E-01	8.95E-02	5.95E-02	5.95E-03	3.85E-03	3.85E-04	3.23E-02	3.23E-03	8.50E-02	8.50E-03	1.92E-02	9.62E-03	5.81E-02	2.91E-02
Benzo(b)fluoranthene	1.77E-01	8.83E-02	3.25E-01	1.63E-01	1.08E-01	1.08E-02	7.00E-03	7.00E-04	5.87E-02	5.87E-03	1.54E-01	1.54E-02	3.49E-02	1.75E-02	1.06E-01	5.28E-02
Benzo(g,h,i)perylene	6.66E-02	3.33E-02	1.23E-01	6.13E-02	4.07E-02	4.07E-03	2.64E-03	2.64E-04	2.21E-02	2.21E-03	5.81E-02	5.81E-03	1.32E-02	6.58E-03	3.98E-02	1.99E-02
Benzo(k)fluoranthene	6.66E-02	3.33E-02	1.23E-01	6.13E-02	4.07E-02	4.07E-03	2.64E-03	2.64E-04	2.21E-02	2.21E-03	5.81E-02	5.81E-03	1.32E-02	6.58E-03	3.98E-02	1.99E-02
Butylbenzylphthalate	5.02E-04	5.02E-05	9.25E-04	9.25E-05	NA	NA	NA	NA	NA	NA	NA	NA	9.93E-05	9.93E-06	3.00E-04	3.00E-05
Chrysene	1.23E-01	6.14E-02	2.26E-01	1.13E-01	7.52E-02	7.52E-03	4.87E-03	4.87E-04	4.08E-02	4.08E-03	1.07E-01	1.07E-02	2.43E-02	1.21E-02	7.34E-02	3.67E-02
Fluoranthene	9.98E-02	4.99E-02	1.84E-01	9.19E-02	6.11E-02	6.11E-03	3.96E-03	3.96E-04	3.32E-02	3.32E-03	8.72E-02	8.72E-03	1.97E-02	9.87E-03	5.97E-02	2.98E-02
Indeno(1,2,3-cd)pyrene	7.68E-02	3.84E-02	1.41E-01	7.07E-02	4.70E-02	4.70E-03	3.04E-03	3.04E-04	2.55E-02	2.55E-03	6.71E-02	6.71E-03	1.52E-02	7.59E-03	4.59E-02	2.29E-02
Phenanthrene	5.12E-02	2.56E-02	9.42E-02	4.71E-02	3.13E-02	3.13E-03	2.03E-03	2.03E-04	1.70E-02	1.70E-03	4.47E-02	4.47E-03	1.01E-02	5.06E-03	3.06E-02	1.53E-02
Pyrene	1.20E-01	6.02E-02	2.21E-01	1.11E-01	7.36E-02	7.36E-03	4.77E-03	4.77E-04	4.00E-02	4.00E-03	1.05E-01	1.05E-02	2.38E-02	1.19E-02	7.19E-02	3.60E-02
Dinitrotoluene, 2,4-	1.13E-01	1.51E-02	2.08E-01	2.78E-02	NA	NA	NA	NA	NA	NA	NA	NA	2.24E-02	2.98E-03	6.76E-02	9.02E-03
Aluminum	1.93E+03	1.93E+02	3.56E+03	3.56E+02	1.60E+02	1.60E+01	1.04E+01	1.04E+00	8.68E+01	8.68E+00	2.28E+02	2.28E+01	3.82E+02	3.82E+01	1.15E+03	1.15E+02
Beryllium	3.39E-01	3.39E-02	6.24E-01	6.24E-02	NA	NA	NA	NA	NA	NA	NA	NA	6.70E-02	6.70E-03	2.03E-01	2.03E-02
Chromium	1.65E+02	1.65E+01	3.04E+02	3.04E+01	1.94E+02	1.94E+01	1.26E+01	1.26E+00	1.05E+02	1.05E+00	2.77E+02	2.77E+00	3.26E+01	3.26E+00	9.87E+01	9.87E+00
Copper	4.86E+00	4.86E-01	8.95E+00	8.95E-01	9.73E+01	9.73E+00	6.30E+00	6.30E-01	5.28E+01	5.28E+00	1.39E+02	1.39E+01	9.61E-01	9.61E-02	2.91E+00	2.91E-01
Iron	7.79E+01	7.79E+00	1.43E+02	1.43E+01	1.83E+02	1.83E+01	1.19E+01	1.19E+00	9.95E+01	9.95E+00	2.62E+02	2.62E+01	1.54E+01	1.54E+00	4.66E+01	4.66E+00
Lead	1.38E+02	1.38E+01	2.54E+02	2.54E+01	3.25E+02	3.25E+01	2.11E+01	2.11E+00	1.77E+02	1.77E+01	4.64E+02	4.64E+01	2.73E+01	2.73E+00	8.26E+01	8.26E+00
Manganese	4.77E-01	4.77E-02	8.77E-01	8.77E-02	1.98E-01	1.98E-02	1.28E-02	1.28E-03	1.07E-01	1.07E-02	2.83E-01	2.83E-02	9.42E-02	9.42E-03	2.85E-01	2.85E-02
Nickel	3.89E-02	3.89E-03	7.15E-02	7.15E-03	NA	NA	NA	NA	NA	NA	NA	NA	7.69E-03	7.69E-04	2.32E-02	2.32E-03
Vanadium	3.33E+01	3.33E+00	6.13E+01	6.13E+00	2.75E+00	2.75E-01	1.78E-01	1.78E-02	1.49E+00	1.49E-01	3.93E+00	3.93E-01	6.58E+00	6.58E-01	1.99E+01	1.99E+00
Zinc	5.79E-01	5.79E-02	1.07E+00	1.07E-01	4.90E+00	4.90E-01	3.17E-01	3.17E-02	2.66E+00	2.66E-01	7.00E+00	7.00E-01	1.15E-01	1.15E-02	3.46E-01	3.46E-02

NA - Not Available

TABLE 7-16

TERRESTRIAL SPECIES - LESS CONSERVATIVE INPUTS
MEAN CONCENTRATION HAZARD QUOTIENT VALUES
SITE 1
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Ecological Contaminants of Concern	Vole		Shrew		Robin		Hawk		Woodcock		Wren		Fox		Mouse	
	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l
Benzo(a)anthracene	4.37E-02	2.19E-02	8.05E-02	4.02E-02	2.68E-02	2.68E-03	1.73E-03	1.73E-04	1.45E-02	1.45E-03	3.82E-03	3.82E-04	8.65E-03	4.32E-03	2.61E-02	1.31E-02
Benzo(a)pyrene	4.36E-02	2.18E-02	8.03E-02	4.02E-02	2.67E-02	2.67E-03	1.73E-03	1.73E-04	1.45E-02	1.45E-03	3.81E-03	3.81E-04	8.63E-03	4.31E-03	2.61E-02	1.30E-02
Benzo(b)fluoranthene	4.69E-02	2.35E-02	8.64E-02	4.32E-02	2.87E-02	2.87E-03	1.86E-03	1.86E-04	1.56E-02	1.56E-03	4.10E-03	4.10E-04	9.28E-03	4.64E-03	2.81E-02	1.40E-02
Benzo(g,h,i)perylene	3.99E-02	1.99E-02	7.34E-02	3.67E-02	2.44E-02	2.44E-03	1.58E-03	1.58E-04	1.32E-02	1.32E-03	3.48E-03	3.48E-04	7.88E-03	3.94E-03	2.38E-02	1.19E-02
Benzo(k)fluoranthene	4.15E-02	2.08E-02	7.65E-02	3.82E-02	2.54E-02	2.54E-03	1.65E-03	1.65E-04	1.38E-02	1.38E-03	3.63E-03	3.63E-04	8.21E-03	4.11E-03	2.48E-02	1.24E-02
Butylbenzylphthalate	3.87E-04	3.87E-05	7.12E-04	7.12E-05	NA	NA	NA	NA	NA	NA	NA	NA	7.65E-05	7.65E-06	2.31E-04	2.31E-05
Chrysene	4.47E-02	2.23E-02	8.23E-02	4.11E-02	2.73E-02	2.73E-03	1.77E-03	1.77E-04	1.48E-02	1.48E-03	3.90E-03	3.90E-04	8.84E-03	4.42E-03	2.67E-02	1.34E-02
Fluoranthene	4.53E-02	2.26E-02	8.33E-02	4.17E-02	2.77E-02	2.77E-03	1.79E-03	1.79E-04	1.50E-02	1.50E-03	3.95E-03	3.95E-04	8.95E-03	4.48E-03	2.71E-02	1.35E-02
Indeno(1,2,3-cd)pyrene	4.12E-02	2.06E-02	7.59E-02	3.80E-02	2.52E-02	2.52E-03	1.63E-03	1.63E-04	1.37E-02	1.37E-03	3.60E-03	3.60E-04	8.15E-03	4.08E-03	2.46E-02	1.23E-02
Phenanthrene	4.86E-02	2.43E-02	8.95E-02	4.48E-02	2.98E-02	2.98E-03	1.93E-03	1.93E-04	1.62E-02	1.62E-03	4.25E-03	4.25E-04	9.62E-03	4.81E-03	2.91E-02	1.45E-02
Pyrene	4.58E-02	2.29E-02	8.44E-02	4.22E-02	2.81E-02	2.81E-03	1.82E-03	1.82E-04	1.52E-02	1.52E-03	4.00E-03	4.00E-04	9.07E-03	4.53E-03	2.74E-02	1.37E-02
Dinitrotoluene, 2,4-	3.06E-01	4.08E-02	5.63E-01	7.50E-02	NA	NA	NA	NA	NA	NA	NA	NA	6.04E-02	8.06E-03	1.83E-01	2.44E-02
Aluminum	8.42E+02	8.42E+01	1.55E+03	1.55E+02	6.97E+01	6.97E+00	4.51E+00	4.51E-01	3.78E+01	3.78E+00	9.95E+00	9.95E-01	1.66E+02	1.66E+01	5.03E+02	5.03E+01
Beryllium	1.54E-01	1.54E-02	2.84E-01	2.84E-02	NA	NA	NA	NA	NA	NA	NA	NA	3.05E-02	3.05E-03	9.21E-02	9.21E-03
Chromium	8.65E+01	8.65E+00	1.59E+02	1.59E+01	1.02E+02	1.02E+01	6.59E+00	6.59E-01	5.53E+01	5.53E-01	1.45E+01	1.45E-01	1.71E+01	1.71E+00	5.17E+01	5.17E+00
Copper	1.19E+00	1.19E-01	2.19E+00	2.19E-01	2.39E+01	2.39E+00	1.55E+00	1.55E-01	1.30E+01	1.30E+00	3.41E+00	3.41E-01	2.36E-01	2.36E-02	7.14E-01	7.14E-02
Iron	3.69E+01	3.69E+00	6.80E+01	6.80E+00	8.69E+01	8.69E+00	5.63E+00	5.63E-01	4.71E+01	4.71E+00	1.24E+01	1.24E+00	7.30E+00	7.30E-01	2.21E+01	2.21E+00
Lead	2.13E+01	2.13E+00	3.93E+01	3.93E+00	5.02E+01	5.02E+00	3.25E+00	3.25E-01	2.73E+01	2.73E+00	7.17E+00	7.17E-01	4.22E+00	4.22E-01	1.28E+01	1.28E+00
Manganese	2.01E-01	2.01E-02	3.71E-01	3.71E-02	8.36E-02	8.36E-03	5.42E-03	5.42E-04	4.54E-02	4.54E-03	1.19E-02	1.19E-03	3.98E-02	3.98E-03	1.20E-01	1.20E-02
Nickel	1.83E-02	1.83E-03	3.36E-02	3.36E-03	NA	NA	NA	NA	NA	NA	NA	NA	3.61E-03	3.61E-04	1.09E-02	1.09E-03
Vanadium	1.68E+01	1.68E+00	3.09E+01	3.09E+00	1.39E+00	1.39E-01	9.01E-02	9.01E-03	7.55E-01	7.55E-02	1.99E-01	1.99E-02	3.33E+00	3.33E-01	1.01E+01	1.01E+00
Zinc	2.12E-01	2.12E-02	3.90E-01	3.90E-02	1.79E+00	1.79E-01	1.16E-01	1.16E-02	9.73E-01	9.73E-02	2.56E-01	2.56E-02	4.19E-02	4.19E-03	1.27E-01	1.27E-02

NA - Not Available

TABLE 7-17

TERRESTRIAL SPECIES - HAZARD QUOTIENT VALUES SUMMARY
SITE 1
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

	Most Conservative			Least Conservative			Least Cons. Risk Drivers Above Background
Receptor	HQ>100	100>HQ>10	10>HQ>1	HQ>100	100>HQ>10	10>HQ>1	
Vole	Aluminum Chromium Lead	Iron Vanadium	Copper		Aluminum	Chromium Iron Lead Vanadium	Copper* Lead
Shrew	Aluminum Chromium Iron Lead	Copper Vanadium	Zinc	Aluminum	Chromium	Iron Lead Vanadium	
Robin	Aluminum Chromium Copper Iron Lead		Vanadium Zinc		Chromium	Aluminum Copper Iron Lead	
Hawk		Aluminum Chromium Copper Iron Lead	Zinc				
Woodcock	Lead	Aluminum Chromium Copper Iron	Zinc			Aluminum Copper Iron Lead	
Wren	Chromium Iron Lead	Aluminum Copper	Vanadium Zinc			Iron	
Fox	Aluminum	Chromium Iron Lead Vanadium	Copper		Aluminum	Chromium	
Mouse	Aluminum	Chromium Iron Lead Vanadium	Copper		Aluminum Chromium	Iron Lead Vanadium	

Notes:

HQ Hazard Quotient
ECOC Ecological Contaminant of Concern
* Concentrations were below surface soil screening levels, but constituent included in the models as a surface water ECOC

TABLE 7-18

COMPARISON OF FLORA AND FAUNA BENCHMARK VALUES TO SURFACE SOIL CONCENTRATIONS
SITE 3 PROPER
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Ecological Contaminant of Concern	Maximum Concentration	No. of Positive Detects/ No. of Samples	Flora			Fauna			Normal 95% UCL Background Surface Soil
			Benchmark	Reference	HQ	Benchmark	Reference	HQ	
Semivolatiles (µg/kg)									
Benzo(a)anthracene	120J	1/15	NE	NA	NA	NE	NA	NA	240J*
Benzo(a)pyrene	160J	1/15	NE	NA	NA	25,000	a-invert.	0.01	180J*
Benzo(b)fluoranthene	220J	1/15	NE	NA	NA	NE	NA	NA	500*
Chrysene	170J	1/15	NE	NA	NA	NE	NA	NA	270J*
Fluoranthene	140J	1/15	NE	NA	NA	NE	NA	NA	430*
Phenanthrene	220J	1/15	NE	NA	NA	99,900	b-browner earthworm	0.002	ND
Pyrene	240J	1/15	NE	NA	NA	NE	NA	NA	320J*
Inorganics (mg/kg)									
Aluminum	11,800	15/15	50	a-plants	236.00	600	a-microorg.	19.67	14,831
Antimony	16.8L	2/15	0.5	a-plants	33.60	NE	NA	NA	ND
Beryllium	1.5	14/15	10	a-plants	0.15	NE	NA	NA	0.34
Chromium	31.6K	15/15	1	a-plants	31.6	0.15	a-earthworm	210.67	19.38
Cyanide	0.89	1/15	NE	NA	NA	NE	NA	NA	ND
Iron	23,800	15/15	NE	NA	NA	200	a-microorg.	119.00	23,981
Lead	74.3	15/15	50	a-plants	1.49	500	a-earthworm	0.15	9.36
Manganese	667	15/15	50	a-plants	13.34	10	a-microorg.	66.7	65.84
Mercury	0.11	2/15	0.03	a-plants	3.67	0.05	a-earthworm	2.20	0.03
Nickel	8.9	11/15	30	a-plants	0.30	90	a-microorg.	0.10	6.65

TABLE 7-18 (Continued)

COMPARISON OF FLORA AND FAUNA BENCHMARK VALUES TO SURFACE SOIL CONCENTRATIONS
SITE 3 PROPER
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Ecological Contaminant of Concern	Maximum Concentration	No. of Positive Detects/ No. of Samples	Flora			Fauna			Normal 95% UCL Background Surface Soil
			Benchmark	Reference	HQ	Benchmark	Reference	HQ	
Thallium	0.23K	1/15	0.1	a-plants	2.30	NE	NA	NA	ND
Vanadium	37.7	15/15	2	a-plants	18.85	2	a-microorg.	1.89	36.65
Zinc	203	13/15	50	a-plants	4.06	10	a-microorg.	20.30	15.53

Notes:

Highlighted areas represent hazard quotients greater than one.
* Maximum background value presented because the UCL is greater than the maximum value.

a - Will and Suter, 1995a/b
b - Browner et al., 1993

HQ Hazard Quotient (equivalent to benchmark divided by maximum concentration)
NE Not Established
NA Not Applicable
ND Not Detected
J Analyte was positively identified, value is estimated
K Estimated value, biased high
L Estimated value, biased low
UCL Upper Confidence Level

TABLE 7-19

TERRESTRIAL SPECIES - CONSERVATIVE INPUTS
MAXIMUM CONCENTRATION HAZARD QUOTIENT VALUES
SITE 3 PROPER
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Ecological Contaminant of Concern	Vole		Shrew		Robin		Hawk		Woodcock		Wren		Fox		Mouse	
	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l
Benzo(a)anthracene	3.31E-02	1.65E-02	6.32E-02	3.16E-02	2.37E-02	2.37E-03	5.05E-03	5.05E-04	6.58E-03	6.58E-04	1.16E-02	1.16E-03	1.23E-02	6.17E-03	1.80E-02	8.98E-03
Benzo(a)pyrene	4.41E-02	2.21E-02	8.42E-02	4.21E-02	3.16E-02	3.16E-03	6.73E-03	6.73E-04	8.78E-03	8.78E-04	1.54E-02	1.54E-03	1.65E-02	8.23E-03	2.40E-02	1.20E-02
Benzo(b)fluoranthene	6.07E-02	3.03E-02	1.16E-01	5.79E-02	4.35E-02	4.35E-03	9.26E-03	9.26E-04	1.21E-02	1.21E-03	2.12E-02	2.12E-03	2.26E-02	1.13E-02	3.29E-02	1.65E-02
Chrysene	4.69E-02	2.34E-02	8.95E-02	4.48E-02	3.36E-02	3.36E-03	7.16E-03	7.16E-04	9.32E-03	9.32E-04	1.64E-02	1.64E-03	1.75E-02	8.75E-03	2.55E-02	1.27E-02
Fluoranthene	3.86E-02	1.93E-02	7.37E-02	3.69E-02	2.77E-02	2.77E-03	5.89E-03	5.89E-04	7.68E-03	7.68E-04	1.35E-02	1.35E-03	1.44E-02	7.20E-03	2.10E-02	1.05E-02
Phenanthrene	6.07E-02	3.03E-02	1.16E-01	5.79E-02	4.35E-02	4.35E-03	9.26E-03	9.26E-04	1.21E-02	1.21E-03	2.12E-02	2.12E-03	2.26E-02	1.13E-02	3.29E-02	1.65E-02
Pyrene	6.62E-02	3.31E-02	1.26E-01	6.32E-02	4.74E-02	4.74E-03	1.01E-02	1.01E-03	1.32E-02	1.32E-03	2.31E-02	2.31E-03	2.47E-02	1.23E-02	3.59E-02	1.80E-02
Aluminum	2.19E+03	2.19E+02	4.19E+03	4.19E+02	2.13E+02	2.13E+01	4.53E+01	4.53E+00	5.90E+01	5.90E+00	1.04E+02	1.04E+01	8.18E+02	8.18E+01	1.19E+03	1.19E+02
Antimony	1.72E+02	1.72E+01	3.29E+02	3.29E+01	NA	NA	NA	NA	NA	NA	NA	NA	6.42E+01	6.42E+00	9.34E+01	9.34E+00
Beryllium	9.96E-01	9.96E-02	1.90E+00	1.90E-01	NA	NA	NA	NA	NA	NA	NA	NA	3.72E-01	3.72E-02	5.41E-01	5.41E-02
Chromium	4.53E+02	4.53E+01	8.65E+02	8.65E+01	6.24E+02	6.24E+01	1.33E+02	1.33E+01	1.73E+02	1.73E+00	3.05E+02	3.05E+00	1.69E+02	1.69E+01	2.46E+02	2.46E+01
Copper	4.63E+00	4.63E-01	8.83E+00	8.83E-01	1.08E+02	1.08E+01	2.31E+01	2.31E+00	3.01E+01	3.01E+00	5.29E+01	5.29E+00	1.73E+00	1.73E-01	2.51E+00	2.51E-01
Cyanide	3.99E-01	3.99E-02	7.61E-01	7.61E-02	3.91E-01	3.91E-02	8.32E-02	8.32E-03	1.08E-01	1.08E-02	1.91E-01	1.91E-02	1.49E-01	1.49E-02	2.17E-01	2.17E-02
Iron	1.71E+02	1.71E+01	3.26E+02	3.26E+01	4.70E+02	4.70E+01	1.00E+02	1.00E+01	1.31E+02	1.31E+01	2.29E+02	2.29E+01	6.37E+01	6.37E+00	9.27E+01	9.27E+00
Lead	1.78E+02	1.78E+01	3.39E+02	3.39E+01	4.89E+02	4.89E+01	1.04E+02	1.04E+01	1.36E+02	1.36E+01	2.39E+02	2.39E+01	6.63E+01	6.63E+00	9.64E+01	9.64E+00
Manganese	2.72E+00	2.72E-01	5.19E+00	5.19E-01	1.32E+00	1.32E-01	2.82E-01	2.82E-02	3.67E-01	3.67E-02	6.45E-01	6.45E-02	1.01E+00	1.01E-01	1.48E+00	1.48E-01
Mercury	7.88E-01	7.88E-02	1.51E+00	1.51E-01	2.17E+01	2.17E+00	4.63E+00	4.63E-01	5.03E+00	5.03E-01	8.84E+00	8.84E-01	1.47E+00	1.47E-01	4.28E-01	4.28E-02
Nickel	5.10E-02	5.10E-03	9.75E-02	9.75E-03	NA	NA	NA	NA	NA	NA	NA	NA	1.91E-02	1.91E-03	2.77E-02	2.77E-03
Thallium	3.58E-01	1.11E-01	6.84E-01	2.13E-01	NA	NA	NA	NA	NA	NA	NA	NA	1.34E-01	4.16E-02	1.95E-01	6.05E-02
Vanadium	6.76E+01	6.76E+00	1.29E+02	1.29E+01	6.55E+00	6.55E-01	1.40E+00	1.39E-01	1.82E+00	1.82E-01	3.19E+00	3.19E-01	2.52E+01	2.52E+00	3.67E+01	3.67E+00
Zinc	2.91E+00	2.91E-01	5.56E+00	5.56E-01	2.89E+01	2.89E+00	6.15E+00	6.15E-01	8.01E+00	8.01E-01	1.41E+01	1.41E+00	1.09E+00	1.09E-01	1.58E+00	1.58E-01

NA - Not Available

TABLE 7-20

TERRESTRIAL SPECIES - CONSERVATIVE INPUTS
MEAN CONCENTRATION HAZARD QUOTIENT VALUES
SITE 3 PROPER
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

	Vole		Shrew		Robin		Hawk		Woodcock		Wren		Fox		Mouse	
Ecological Contaminant of Concern	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l
Benzo(a)anthracene	5.32E-02	2.66E-02	1.02E-01	5.08E-02	3.81E-02	3.81E-03	8.12E-03	8.12E-04	1.06E-02	1.06E-03	1.86E-02	1.86E-03	1.99E-02	9.93E-03	2.89E-02	1.45E-02
Benzo(a)pyrene	5.39E-02	2.70E-02	1.03E-01	5.15E-02	3.87E-02	3.87E-03	8.24E-03	8.24E-04	1.07E-02	1.07E-03	1.89E-02	1.89E-03	2.01E-02	1.01E-02	2.93E-02	1.47E-02
Benzo(b)fluoranthene	5.50E-02	2.75E-02	1.05E-01	5.26E-02	3.95E-02	3.95E-03	8.40E-03	8.40E-04	1.10E-02	1.10E-03	1.93E-02	1.93E-03	2.05E-02	1.03E-02	2.99E-02	1.49E-02
Chrysene	5.41E-02	2.71E-02	1.03E-01	5.17E-02	3.88E-02	3.88E-03	8.26E-03	8.26E-04	1.08E-02	1.08E-03	1.89E-02	1.89E-03	2.02E-02	1.01E-02	2.94E-02	1.47E-02
Fluoranthene	5.36E-02	2.68E-02	1.02E-01	5.12E-02	3.84E-02	3.84E-03	8.18E-03	8.18E-04	1.07E-02	1.07E-03	1.87E-02	1.87E-03	2.00E-02	1.00E-02	2.91E-02	1.45E-02
Phenanthrene	5.50E-02	2.75E-02	1.05E-01	5.26E-02	3.95E-02	3.95E-03	8.40E-03	8.40E-04	1.10E-02	1.10E-03	1.93E-02	1.93E-03	2.05E-02	1.03E-02	2.99E-02	1.49E-02
Pyrene	5.54E-02	2.77E-02	1.06E-01	5.29E-02	3.97E-02	3.97E-03	8.46E-03	8.46E-04	1.10E-02	1.10E-03	1.94E-02	1.94E-03	2.07E-02	1.03E-02	3.01E-02	1.50E-02
Aluminum	8.45E+02	8.45E+01	1.61E+03	1.61E+02	8.19E+01	8.19E+00	1.74E+01	1.74E+00	2.27E+01	2.27E+00	4.00E+01	4.00E+00	3.15E+02	3.15E+01	4.59E+02	4.59E+01
Antimony	3.29E+01	3.29E+00	6.26E+01	6.26E+00	NA	NA	NA	NA	NA	NA	NA	NA	1.22E+01	1.22E+00	1.78E+01	1.78E+00
Beryllium	3.25E-01	3.25E-02	6.21E-01	6.21E-02	NA	NA	NA	NA	NA	NA	NA	NA	1.21E-01	1.21E-02	1.77E-01	1.77E-02
Chromium	1.49E+02	1.49E+01	2.84E+02	2.84E+01	2.05E+02	2.05E+01	4.36E+01	4.36E+00	5.68E+01	5.68E+01	9.99E+01	9.99E+01	5.54E+01	5.54E+00	8.07E+01	8.07E+00
Copper	1.40E+00	1.40E-01	2.67E+00	2.67E-01	3.28E+01	3.28E+00	6.99E+00	6.99E-01	9.11E+00	9.11E-01	1.60E+01	1.60E+00	5.22E-01	5.22E-02	7.60E-01	7.60E-02
Cyanide	1.30E-01	1.30E-02	2.48E-01	2.48E-02	1.27E-01	1.27E-02	2.71E-02	2.71E-03	3.53E-02	3.53E-03	6.21E-02	6.21E-03	4.85E-02	4.85E-03	7.06E-02	7.06E-03
Iron	5.97E+01	5.97E+00	1.14E+02	1.14E+01	1.65E+02	1.65E+01	3.51E+01	3.51E+00	4.57E+01	4.57E+00	8.03E+01	8.03E+00	2.23E+01	2.23E+00	3.24E+01	3.24E+00
Lead	3.82E+01	3.82E+00	7.29E+01	7.29E+00	1.05E+02	1.05E+01	2.24E+01	2.24E+00	2.92E+01	2.92E+00	5.14E+01	5.14E+00	1.43E+01	1.43E+00	2.07E+01	2.07E+00
Manganese	4.94E-01	4.94E-02	9.44E-01	9.44E-02	2.40E-01	2.40E-02	5.12E-02	5.12E-03	6.67E-02	6.67E-03	1.17E-01	1.17E-02	1.84E-01	1.84E-02	2.68E-01	2.68E-02
Mercury	2.15E-01	2.15E-02	4.11E-01	4.11E-02	5.93E+00	5.93E-01	1.26E+00	1.26E-01	1.37E+00	1.37E-01	2.41E+00	2.41E-01	4.01E-01	4.01E-02	1.17E-01	1.17E-02
Nickel	2.10E-02	2.10E-03	4.01E-02	4.01E-03	NA	NA	NA	NA	NA	NA	NA	NA	7.83E-03	7.83E-04	1.14E-02	1.14E-03
Thallium	2.03E-01	6.30E-02	3.87E-01	1.20E-01	NA	NA	NA	NA	NA	NA	NA	NA	7.56E-02	2.35E-02	1.10E-01	3.42E-02
Vanadium	2.85E+01	2.85E+00	5.43E+01	5.43E+00	2.76E+00	2.76E-01	5.88E-01	5.87E-02	7.65E-01	7.65E-02	1.34E+00	1.34E-01	1.06E+01	1.06E+00	1.55E+01	1.55E+00
Zinc	4.53E-01	4.53E-02	8.64E-01	8.64E-02	4.49E+00	4.49E-01	9.56E-01	9.56E-02	1.25E+00	1.25E-01	2.19E+00	2.19E-01	1.69E-01	1.69E-02	2.46E-01	2.46E-02

NA - Not Available

TABLE 7-21

TERRESTRIAL SPECIES - LESS CONSERVATIVE INPUTS
MAXIMUM CONCENTRATION HAZARD QUOTIENT VALUES
SITE 3 PROPER
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Ecological Contaminant of Concern	Vole		Shrew		Robin		Hawk		Woodcock		Wren		Fox		Mouse	
	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l
Benzo(a)anthracene	3.07E-02	1.54E-02	5.65E-02	2.83E-02	1.88E-02	1.88E-03	1.22E-03	1.22E-04	1.02E-02	1.02E-03	2.68E-03	2.68E-04	6.07E-03	3.04E-03	1.84E-02	9.18E-03
Benzo(a)pyrene	4.10E-02	2.05E-02	7.54E-02	3.77E-02	2.51E-02	2.51E-03	1.62E-03	1.62E-04	1.36E-02	1.36E-03	3.58E-03	3.58E-04	8.10E-03	4.05E-03	2.45E-02	1.22E-02
Benzo(b)fluoranthene	5.63E-02	2.82E-02	1.04E-01	5.18E-02	3.45E-02	3.45E-03	2.23E-03	2.23E-04	1.87E-02	1.87E-03	4.92E-03	4.92E-04	1.11E-02	5.57E-03	3.37E-02	1.68E-02
Chrysene	4.35E-02	2.18E-02	8.01E-02	4.01E-02	2.66E-02	2.66E-03	1.72E-03	1.72E-04	1.45E-02	1.45E-03	3.80E-03	3.80E-04	8.60E-03	4.30E-03	2.60E-02	1.30E-02
Fluoranthene	3.58E-02	1.79E-02	6.60E-02	3.30E-02	2.19E-02	2.19E-03	1.42E-03	1.42E-04	1.19E-02	1.19E-03	3.13E-03	3.13E-04	7.09E-03	3.54E-03	2.14E-02	1.07E-02
Phenanthrene	5.63E-02	2.82E-02	1.04E-01	5.18E-02	3.45E-02	3.45E-03	2.23E-03	2.23E-04	1.87E-02	1.87E-03	4.92E-03	4.92E-04	1.11E-02	5.57E-03	3.37E-02	1.68E-02
Pyrene	6.14E-02	3.07E-02	1.13E-01	5.65E-02	3.76E-02	3.76E-03	2.43E-03	2.43E-04	2.04E-02	2.04E-03	5.37E-03	5.37E-04	1.21E-02	6.07E-03	3.67E-02	1.84E-02
Aluminum	2.03E+03	2.03E+02	3.75E+03	3.75E+02	1.69E+02	1.69E+01	1.09E+01	1.09E+00	9.14E+01	9.14E+00	2.41E+01	2.41E+00	4.02E+02	4.02E+01	1.22E+03	1.22E+02
Antimony	1.60E+02	1.60E+01	2.94E+02	2.94E+01	NA	NA	NA	NA	NA	NA	NA	NA	3.16E+01	3.16E+00	9.55E+01	9.55E+00
Beryllium	9.24E-01	9.24E-02	1.70E+00	1.70E-01	NA	NA	NA	NA	NA	NA	NA	NA	1.83E-01	1.83E-02	5.52E-01	5.52E-02
Chromium	4.21E+02	4.21E+01	7.74E+02	7.74E+01	4.95E+02	4.95E+01	3.20E+01	3.20E+00	2.69E+02	2.69E+00	7.07E+01	7.07E-01	8.32E+01	8.32E+00	2.51E+02	2.51E+01
Copper	4.29E+00	4.29E-01	7.90E+00	7.90E-01	8.60E+01	8.60E+00	5.57E+00	5.57E-01	4.67E+01	4.67E+00	1.23E+01	1.23E+00	8.49E-01	8.49E-02	2.57E+00	2.57E-01
Cyanide	3.70E-01	3.70E-02	6.81E-01	6.81E-02	3.10E-01	3.10E-02	2.01E-02	2.01E-03	1.68E-01	1.68E-02	4.42E-02	4.42E-03	7.32E-02	7.32E-03	2.21E-01	2.21E-02
Iron	1.58E+02	1.58E+01	2.92E+02	2.92E+01	3.73E+02	3.73E+01	2.41E+01	2.41E+00	2.02E+02	2.02E+01	5.32E+01	5.32E+00	3.13E+01	3.13E+00	9.47E+01	9.47E+00
Lead	1.65E+02	1.65E+01	3.03E+02	3.03E+01	3.88E+02	3.88E+01	2.51E+01	2.51E+00	2.11E+02	2.11E+01	5.54E+01	5.54E+00	3.26E+01	3.26E+00	9.85E+01	9.85E+00
Manganese	2.52E+00	2.52E-01	4.64E+00	4.64E-01	1.05E+00	1.05E-01	6.78E-02	6.78E-03	5.69E-01	5.69E-02	1.50E-01	1.50E-02	4.99E-01	4.99E-02	1.51E+00	1.51E-01
Mercury	7.32E-01	7.32E-02	1.35E+00	1.35E-01	1.72E+01	1.72E+00	1.12E+00	1.12E-01	7.79E+00	7.79E-01	2.05E+00	2.05E-01	7.24E-01	7.24E-02	4.38E-01	4.38E-02
Nickel	4.74E-02	4.74E-03	8.72E-02	8.72E-03	NA	NA	NA	NA	NA	NA	NA	NA	9.37E-03	9.37E-04	2.83E-02	2.83E-03
Thallium	3.33E-01	1.03E-01	6.13E-01	1.90E-01	NA	NA	NA	NA	NA	NA	NA	NA	6.58E-02	2.05E-02	1.99E-01	6.18E-02
Vanadium	6.27E+01	6.27E+00	1.15E+02	1.15E+01	5.19E+00	5.19E-01	3.36E-01	3.36E-02	2.82E+00	2.82E-01	7.41E-01	7.41E-02	1.24E+01	1.24E+00	3.75E+01	3.75E+00
Zinc	2.70E+00	2.70E-01	4.97E+00	4.97E-01	2.29E+01	2.29E+00	1.48E+00	1.48E-01	1.24E+01	1.24E+00	3.27E+00	3.27E-01	5.34E-01	5.34E-02	1.62E+00	1.62E-01

NA - Not Available

TABLE 7-22

TERRESTRIAL SPECIES - LESS CONSERVATIVE INPUTS
MEAN CONCENTRATION HAZARD QUOTIENT VALUES
SITE 3 PROPER
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

	Vole		Shrew		Robin		Hawk		Woodcock		Wren		Fox		Mouse	
Ecological Contaminant of Concern	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l
Benzo(a)anthracene	4.94E-02	2.47E-02	9.09E-02	4.55E-02	3.02E-02	3.02E-03	1.96E-03	1.96E-04	1.64E-02	1.64E-03	4.32E-03	4.32E-04	9.77E-03	4.88E-03	2.95E-02	1.48E-02
Benzo(a)pyrene	5.01E-02	2.50E-02	9.22E-02	4.61E-02	3.07E-02	3.07E-03	1.98E-03	1.98E-04	1.66E-02	1.66E-03	4.38E-03	4.38E-04	9.90E-03	4.95E-03	2.99E-02	1.50E-02
Benzo(b)fluoranthene	5.11E-02	2.56E-02	9.41E-02	4.70E-02	3.13E-02	3.13E-03	2.02E-03	2.02E-04	1.70E-02	1.70E-03	4.46E-03	4.46E-04	1.01E-02	5.05E-03	3.05E-02	1.53E-02
Chrysene	5.03E-02	2.51E-02	9.25E-02	4.63E-02	3.08E-02	3.08E-03	1.99E-03	1.99E-04	1.67E-02	1.67E-03	4.39E-03	4.39E-04	9.94E-03	4.97E-03	3.00E-02	1.50E-02
Fluoranthene	4.97E-02	2.49E-02	9.16E-02	4.58E-02	3.04E-02	3.04E-03	1.97E-03	1.97E-04	1.65E-02	1.65E-03	4.35E-03	4.35E-04	9.84E-03	4.92E-03	2.97E-02	1.49E-02
Phenanthrene	5.11E-02	2.56E-02	9.41E-02	4.70E-02	3.13E-02	3.13E-03	2.02E-03	2.02E-04	1.70E-02	1.70E-03	4.46E-03	4.46E-04	1.01E-02	5.05E-03	3.05E-02	1.53E-02
Pyrene	5.15E-02	2.57E-02	9.47E-02	4.74E-02	3.15E-02	3.15E-03	2.04E-03	2.04E-04	1.71E-02	1.71E-03	4.49E-03	4.49E-04	1.02E-02	5.09E-03	3.08E-02	1.54E-02
Aluminum	7.84E+02	7.84E+01	1.44E+03	1.44E+02	6.49E+01	6.49E+00	4.20E+00	4.20E-01	3.52E+01	3.52E+00	9.27E+00	9.27E-01	1.55E+02	1.55E+01	4.69E+02	4.69E+01
Antimony	3.04E+01	3.04E+00	5.60E+01	5.60E+00	NA	NA	NA	NA	NA	NA	NA	NA	6.02E+00	6.02E-01	1.82E+01	1.82E+00
Beryllium	3.02E-01	3.02E-02	5.56E-01	5.56E-02	NA	NA	NA	NA	NA	NA	NA	NA	5.97E-02	5.97E-03	1.80E-01	1.80E-02
Chromium	1.38E+02	1.38E+01	2.54E+02	2.54E+01	1.62E+02	1.62E+01	1.05E+01	1.05E+00	8.81E+01	8.81E-01	2.32E+01	2.32E-01	2.73E+01	2.73E+00	8.24E+01	8.24E+00
Copper	1.30E+00	1.30E-01	2.39E+00	2.39E-01	2.60E+01	2.60E+00	1.68E+00	1.68E-01	1.41E+01	1.41E+00	3.72E+00	3.72E-01	2.57E-01	2.57E-02	7.77E-01	7.77E-02
Cyanide	1.21E-01	1.21E-02	2.22E-01	2.22E-02	1.01E-01	1.01E-02	6.54E-03	6.54E-04	5.48E-02	5.48E-03	1.44E-02	1.44E-03	2.39E-02	2.39E-03	7.21E-02	7.21E-03
Iron	5.55E+01	5.55E+00	1.02E+02	1.02E+01	1.31E+02	1.31E+01	8.45E+00	8.45E-01	7.08E+01	7.08E+00	1.86E+01	1.86E+00	1.10E+01	1.10E+00	3.31E+01	3.31E+00
Lead	3.55E+01	3.55E+00	6.52E+01	6.53E+00	8.34E+01	8.34E+00	5.40E+00	5.40E-01	4.53E+01	4.53E+00	1.19E+01	1.19E+00	7.01E+00	7.01E-01	2.12E+01	2.12E+00
Manganese	4.59E-01	4.59E-02	8.44E-01	8.44E-02	1.91E-01	1.91E-02	1.23E-02	1.23E-03	1.03E-01	1.03E-02	2.72E-02	2.72E-03	9.07E-02	9.07E-03	2.74E-01	2.74E-02
Mercury	2.00E-01	2.00E-02	3.68E-01	3.68E-02	4.70E+00	4.70E-01	3.04E-01	3.04E-02	2.13E+00	2.13E-01	5.59E-01	5.59E-02	1.97E-01	1.97E-02	1.19E-01	1.19E-02
Nickel	1.95E-02	1.95E-03	3.59E-02	3.59E-03	NA	NA	NA	NA	NA	NA	NA	NA	3.85E-03	3.85E-04	1.16E-02	1.16E-03
Thallium	1.88E-01	5.85E-02	3.46E-01	1.08E-01	NA	NA	NA	NA	NA	NA	NA	NA	3.72E-02	1.16E-02	1.12E-01	3.49E-02
Vanadium	2.64E+01	2.64E+00	4.86E+01	4.86E+00	2.18E+00	2.18E-01	1.42E-01	1.41E-02	1.19E+00	1.19E-01	3.12E-01	3.12E-02	5.22E+00	5.22E-01	1.58E+01	1.58E+00
Zinc	4.20E-01	4.20E-02	7.74E-01	7.74E-02	3.56E+00	3.56E-01	2.30E-01	2.30E-02	1.93E+00	1.93E-01	5.08E-01	5.08E-02	8.31E-02	8.31E-03	2.51E-01	2.51E-02

NA - Not Available

TABLE 7-23

TERRESTRIAL SPECIES - HAZARD QUOTIENT VALUES SUMMARY
SITE 3 PROPER
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

	Most Conservative			Least Conservative			Least Cons. Risk Drivers Above
Receptor	HQ>100	100>HQ>10	10>HQ>1	HQ>100	100>HQ>10	10>HQ>1	Background
Vole	Aluminum Antimony Chromium Iron Lead	Vanadium	Copper Manganese Zinc		Aluminum Chromium	Antimony Iron Lead Vanadium	Antimony Chromium Copper* Lead Vanadium
Shrew	Aluminum Antimony Chromium Iron Lead Vanadium		Beryllium Copper Manganese Mercury Zinc	Aluminum	Chromium Iron	Antimony Lead Vanadium	
Robin	Aluminum Chromium Copper Iron Lead	Mercury Zinc	Manganese Vanadium		Chromium Iron	Aluminum Copper Lead	
Hawk	Chromium Iron Lead	Aluminum Copper	Mercury Vanadium Zinc			Chromium	
Woodcock	Chromium Iron Lead	Aluminum Copper	Mercury Vanadium Zinc			Aluminum Copper Iron Lead	
Wren	Aluminum Chromium Iron Lead	Copper Zinc	Mercury Vanadium			Iron Lead	
Fox	Aluminum Chromium	Antimony Iron Lead Vanadium	Copper Manganese Mercury Zinc		Aluminum	Chromium Iron	
Mouse	Aluminum Chromium	Antimony Iron Lead Vanadium	Copper Manganese Zinc		Aluminum Chromium	Antimony Iron Lead Vanadium	

Notes:

HQ Hazard Quotient
ECOC Ecological Contaminant of Concern
* Concentrations were below surface soil screening levels, but constituent included in the models as a surface water ECOC

TABLE 7-24

COMPARISON OF FLORA AND FAUNA BENCHMARK VALUES TO SURFACE SOIL CONCENTRATIONS
SITE 3, SOIL AREA OF CONCERN
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Analyte	Maximum Concentration	No. of Positive Detects/ No. of Samples	Flora			Fauna			Background Surface Soil Normal 95% UCL
			Benchmark	Reference	HQ	Benchmark	Reference	HQ	
Semivolatiles (µg/kg)									
Acenaphthene	18,000	4/6	NE	NA	NA	NE	NA	NA	ND
Anthracene	47,000	6/6	NE	NA	NA	NE	NA	NA	ND
Benzo(a)anthracene	92,000	6/6	NE	NA	NA	NE	NA	NA	240J*
Benzo(a)pyrene	77,000	6/6	NE	NA	NA	25,000	a-invert.	3.08	180J*
Benzo(b)fluoranthene	98,000	6/6	NE	NA	NA	NE	NA	NA	500*
Benzo(g,h,i)perylene	41,000	6/6	NE	NA	NA	NE	NA	NA	ND
Benzo(k)fluoranthene	32,000	6/6	NE	NA	NA	NE	NA	NA	130J*
Carbazole	37,000	6/6	NE	NA	NA	NE	NA	NA	ND
Chrysene	87,000	6/6	NE	NA	NA	NE	NA	NA	270J*
Dibenzo(a,h,)anthracene	12,000	5/6	NE	NA	NA	NE	NA	NA	ND
Dibenzofuran	14,000	4/6	NE	NA	NA	NE	NA	NA	ND
Fluoranthene	190,000	6/6	NE	NA	NA	NE	NA	NA	430*
Fluorene	22,000	4/6	NE	NA	NA	30,000	a-earthworm	0.73	ND
Indeno(1,2,3-cd)pyrene	147,000	6/6	NE	NA	NA	NE	NA	NA	160J*
2-Methylnaphthalene	4,000J	3/6	NE	NA	NA	NE	NA	NA	ND
Naphthalene	7,300J	4/6	NE	NA	NA	NE	NA	NA	ND
Phenanthrene	200,000	6/6	NE	NA	NA	99,900	b-browner earthworm	2.00	ND

TABLE 7-24 (Continued)

COMPARISON OF BENCHMARK VALUES TO SURFACE SOIL CONCENTRATIONS FOR THE PROTECTION OF FLORA AND FAUNA
SITE 3, SOIL AREA OF CONCERN
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Analyte	Maximum Concentration	No. of Positive Detects/ No. of Samples	Flora			Fauna			Background Surface Soil Normal 95% UCL
			Benchmark	Reference	HQ	Benchmark	Reference	HQ	
Semivolatiles (µg/kg) (continued)									
Pyrene	160,000	6/6	NE	NA	NA	NE	NE	NA	320J*
Inorganics (mg/kg)									
Aluminum	10,100	1/1	50	a-plants	202.00	600	a-microorg.	16.83	14,831
Beryllium	0.98	1/1	10	a-plants	0.10	NE	NA	NA	0.34
Chromium	16	1/1	1	a-plants	16.00	0.15	a-earthworm	106.67	19.38
Iron	8,040	1/1	NE	NA	NA	200	a-microorg.	40.20	23,981
Lead	59.4	1/1	50	a-plants	1.19	500	a-earthworm	0.12	9.36
Manganese	1,580	1/1	50	a-plants	31.60	10	a-microorg.	158.00	65.84
Mercury	0.15	1/1	0.03	a-plants	5.00	0.05	a-earthworm	3.00	0.03
Nickel	21.5	1/1	30	a-plants	0.72	90	a-microorg.	0.24	6.65
Vanadium	142	1/1	2	a-plants	71.00	20	a-microorg.	7.10	36.65
Zinc	180	1/1	50	a-plants	3.60	100	a-microorg.	1.80	15.53

Notes:

Highlighted areas represent hazard quotients greater than one.
* Maximum background value presented because the UCL is greater than the maximum value.

a - Will and Suter, 1995 a/b
b - Browner et al., 1993

TABLE 7-24 (Continued)

COMPARISON OF BENCHMARK VALUES TO SURFACE SOIL CONCENTRATIONS FOR THE PROTECTION OF FLORA AND FAUNA
SITE 3, SOIL AREA OF CONCERN
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

HQ	Hazard Quotient
NE	Not Established
NA	Not Applicable
ND	Not Detected
UCL	Upper Confidence Level
J	Analyte was positively identified, value is estimated

TABLE 7-25

TERRESTRIAL SPECIES - CONSERVATIVE INPUTS
MAXIMUM CONCENTRATION HAZARD QUOTIENT VALUES
SITE 3 - SOIL AREA OF CONCERN
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Ecological Contaminants of Concern	Vole		Shrew		Robin		Hawk		Woodcock		Wren		Fox		Mouse	
	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l
Acenaphthene	4.96E+00	2.48E+00	9.48E+00	4.74E+00	3.56E+00	3.56E-01	7.58E-01	7.58E-02	9.87E-01	9.87E-02	1.74E+00	1.74E-01	1.85E+00	9.26E-01	2.70E+00	1.35E+00
Anthracene	1.30E+01	6.48E+00	2.47E+01	1.24E+01	9.29E+00	9.29E-01	1.98E+00	1.98E-01	2.58E+00	2.58E-01	4.53E+00	4.53E-01	4.84E+00	2.42E+00	7.04E+00	3.52E+00
Benzo(a)anthracene	2.54E+01	1.27E+01	4.84E+01	2.42E+01	1.82E+01	1.82E+00	3.87E+00	3.87E-01	5.05E+00	5.05E-01	8.87E+00	8.87E-01	9.47E+00	4.73E+00	1.38E+01	6.89E+00
Benzo(a)pyrene	2.12E+01	1.06E+01	4.05E+01	2.03E+01	1.52E+01	1.52E+00	3.24E+00	3.24E-01	4.22E+00	4.22E-01	7.42E+00	7.42E-01	7.92E+00	3.96E+00	1.15E+01	5.77E+00
Benzo(b)fluoranthene	2.70E+01	1.35E+01	5.16E+01	2.58E+01	1.94E+01	1.94E+00	4.12E+00	4.12E-01	5.38E+00	5.38E-01	9.45E+00	9.45E-01	1.01E+01	5.04E+00	1.47E+01	7.34E+00
Benzo(g,h,i)perylene	1.13E+01	5.65E+00	2.16E+01	1.08E+01	8.10E+00	8.10E-01	1.73E+00	1.73E-01	2.25E+00	2.25E-01	3.95E+00	3.95E-01	4.22E+00	2.11E+00	6.14E+00	3.07E+00
Benzo(k)fluoranthene	8.82E+00	4.41E+00	1.68E+01	8.42E+00	6.32E+00	6.32E-01	1.35E+00	1.35E-01	1.76E+00	1.76E-01	3.09E+00	3.09E-01	3.29E+00	1.65E+00	4.79E+00	2.40E+00
Carbazole	1.02E+01	5.10E+00	1.95E+01	9.74E+00	7.31E+00	7.31E-01	1.56E+00	1.56E-01	2.03E+00	2.03E-01	3.57E+00	3.57E-01	3.81E+00	1.90E+00	5.54E+00	2.77E+00
Chrysene	2.40E+01	1.20E+01	4.58E+01	2.29E+01	1.72E+01	1.72E+00	3.66E+00	3.66E-01	4.77E+00	4.77E-01	8.39E+00	8.39E-01	8.95E+00	4.48E+00	1.30E+01	6.51E+00
Dibenzo(a,h)anthracene	1.13E+01	5.65E+00	2.16E+01	1.08E+01	8.10E+00	8.10E-01	1.73E+00	1.73E-01	2.25E+00	2.25E-01	3.95E+00	3.95E-01	4.22E+00	2.11E+00	6.14E+00	3.07E+00
Dibenzofuran	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Fluoranthene	3.24E+01	2.62E+01	1.00E+02	5.00E+01	3.75E+01	3.75E+00	8.00E+00	8.00E-01	1.04E+01	1.04E+00	1.83E+01	1.83E+00	1.96E+01	9.76E+00	2.85E+01	1.42E+01
Fluorene	6.07E+00	3.03E+00	1.16E+01	5.79E+00	4.35E+00	4.35E-01	9.26E-01	9.26E-02	1.21E+00	1.21E-01	2.12E+00	2.12E-01	2.26E+00	1.13E+00	3.29E+00	1.65E+00
Indeno(1,2,3-c,d)pyrene	1.30E+01	6.48E+00	2.47E+01	1.24E+01	9.29E+00	9.29E-01	1.98E+00	1.98E-01	2.58E+00	2.58E-01	4.53E+00	4.53E-01	4.84E+00	2.42E+00	7.04E+00	3.52E+00
Methylnaphthalene,2-	1.10E+00	5.51E-01	2.11E+00	1.05E+00	7.90E-01	7.90E-02	1.68E-01	1.68E-02	2.19E-01	2.19E-02	3.86E-01	3.86E-02	4.12E-01	2.06E-01	5.99E-01	2.99E-01
Naphthalene	2.01E+00	1.01E+00	3.84E+00	1.92E+00	1.44E+00	1.44E-01	3.07E-01	3.07E-02	4.00E-01	4.00E-02	7.04E-01	7.04E-02	7.51E-01	3.76E-01	1.09E+00	5.47E-01
Phenanthrene	5.51E+01	2.76E+01	1.05E+02	5.27E+01	3.95E+01	3.95E+00	8.42E+00	8.42E-01	1.10E+01	1.10E+00	1.93E+01	1.93E+00	2.06E+01	1.03E+01	2.99E+01	1.50E+01
Pyrene	4.41E+01	2.21E+01	8.42E+01	4.21E+01	3.16E+01	3.16E+00	6.73E+00	6.73E-01	8.78E+00	8.78E-01	1.54E+01	1.54E+00	1.65E+01	8.23E+00	2.40E+01	1.20E+01
Aluminum	1.88E+03	1.88E+02	3.58E+03	3.58E+02	1.82E+02	1.82E+01	3.88E+01	3.88E+00	5.05E+01	5.05E+00	8.88E+01	8.88E+00	7.00E+02	7.00E+01	1.07E+03	1.02E+02
Beryllium	6.50E-01	6.50E-02	1.24E+00	1.24E-01	NA	NA	NA	NA	NA	NA	NA	NA	2.43E-01	2.43E-02	3.53E-01	3.53E-02
Chromium	2.29E+02	2.29E+01	4.38E+02	4.38E+01	3.16E+02	3.16E+01	6.73E+01	6.73E+00	8.78E+01	8.78E-01	1.54E+02	1.54E+00	8.56E+01	8.56E+00	1.25E+02	1.25E+01
Copper	3.91E+00	3.91E-01	7.46E+00	7.46E-01	9.17E+01	9.17E+00	1.95E+01	1.95E+00	2.54E+01	2.54E+00	4.47E+01	4.47E+00	1.46E+00	1.46E-01	2.12E+00	2.12E-01
Iron	5.76E+01	5.76E+00	1.10E+02	1.10E+01	1.59E+02	1.59E+01	3.38E+01	3.38E+00	4.41E+01	4.41E+00	7.75E+01	7.75E+00	2.15E+01	2.15E+00	3.13E+01	3.13E+00
Lead	1.42E+02	1.42E+01	2.71E+02	2.71E+01	3.91E+02	3.91E+01	8.33E+01	8.33E+00	1.09E+02	1.09E+01	1.91E+02	1.91E+01	5.30E+01	5.30E+00	7.71E+01	7.71E+00
Manganese	6.44E+00	6.44E-01	1.23E+01	1.23E+00	3.13E+00	3.13E-01	6.67E-01	6.67E-02	8.69E-01	8.69E-02	1.53E+00	1.53E-01	2.40E+00	2.40E-01	3.50E+00	3.50E-01
Mercury	1.08E+00	1.08E-01	2.05E+00	2.05E-01	2.96E+01	2.96E+00	6.31E+00	6.31E-01	6.86E+00	6.86E-01	1.21E+01	1.21E+00	2.01E+00	2.01E-01	5.84E-01	5.84E-02
Nickel	1.23E-01	1.23E-02	2.35E-01	2.35E-02	NA	NA	NA	NA	NA	NA	NA	NA	4.60E-02	4.60E-03	6.70E-02	6.70E-03
Vanadium	2.54E+02	2.54E+01	4.86E+02	4.86E+01	2.47E+01	2.47E+00	5.26E+00	5.25E-01	6.84E+00	6.84E-01	1.20E+01	1.20E+00	9.50E+01	9.50E+00	1.38E+02	1.38E+01
Zinc	2.58E+00	2.58E-01	4.93E+00	4.93E-01	2.56E+01	2.56E+00	5.45E+00	5.45E-01	7.10E+00	7.10E-01	1.25E+01	1.25E+00	9.63E-01	9.63E-02	1.40E+00	1.40E-01

NA - Not Available

TABLE 7-26

TERRESTRIAL SPECIES - CONSERVATIVE INPUTS
MEAN CONCENTRATION HAZARD QUOTIENT VALUES
SITE 3 - SOIL AREA OF CONCERN
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Ecological Contaminants of Concern	Vole		Shrew		Robin		Hawk		Woodcock		Wren		Fox		Mouse	
	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l
Acenaphthene	2.62E+00	1.31E+00	5.00E+00	2.50E+00	1.88E+00	1.88E-01	4.00E-01	4.00E-02	5.21E-01	5.21E-02	9.15E-01	9.15E-02	9.77E-01	4.88E-01	1.42E+00	7.11E-01
Anthracene	7.20E+00	3.60E+00	1.37E+01	6.87E+00	5.16E+00	5.16E-01	1.10E+00	1.10E-01	1.43E+00	1.43E-01	2.52E+00	2.52E-01	2.69E+00	1.34E+00	3.91E+00	1.95E+00
Benzo(a)anthracene	1.40E+01	7.02E+00	2.68E+01	1.34E+01	1.01E+01	1.01E+00	2.14E+00	2.14E-01	2.79E+00	2.79E-01	4.91E+00	4.91E-01	5.24E+00	2.62E+00	7.63E+00	3.81E+00
Benzo(a)pyrene	1.22E+01	6.11E+00	2.34E+01	1.17E+01	8.77E+00	8.77E-01	1.87E+00	1.87E-01	2.43E+00	2.43E-01	4.28E+00	4.28E-01	4.56E+00	2.28E+00	6.64E+00	3.32E+00
Benzo(b)fluoranthene	1.55E+01	7.74E+00	2.96E+01	1.48E+01	1.11E+01	1.11E+00	2.36E+00	2.36E-01	3.08E+00	3.08E-01	5.41E+00	5.41E-01	5.78E+00	2.89E+00	8.41E+00	4.20E+00
Benzo(g,h,i)perylene	6.59E+00	3.30E+00	1.26E+01	6.29E+00	4.72E+00	4.72E-01	1.01E+00	1.01E-01	1.31E+00	1.31E-01	2.31E+00	2.31E-01	2.46E+00	1.23E+00	3.58E+00	1.79E+00
Benzo(k)fluoranthene	4.70E+00	2.35E+00	8.98E+00	4.49E+00	3.37E+00	3.37E-01	7.18E-01	7.18E-02	9.35E-01	9.35E-02	1.64E+00	1.64E-01	1.75E+00	8.77E-01	2.55E+00	1.28E+00
Carbazole	5.55E+00	2.77E+00	1.06E+01	5.30E+00	3.97E+00	3.97E-01	8.47E-01	8.47E-02	1.10E+00	1.10E-01	1.94E+00	1.94E-01	2.07E+00	1.04E+00	3.01E+00	1.51E+00
Chrysene	1.37E+01	6.85E+00	2.62E+01	1.31E+01	9.82E+00	9.82E-01	2.09E+00	2.09E-01	2.72E+00	2.72E-01	4.79E+00	4.79E-01	5.11E+00	2.56E+00	7.44E+00	3.72E+00
Dibenzo(a,h)anthracene	1.76E+00	8.82E-01	3.37E+00	1.69E+00	1.26E+00	1.26E-01	2.69E-01	2.69E-02	3.51E-01	3.51E-02	6.17E-01	6.17E-02	6.59E-01	3.29E-01	9.58E-01	4.79E-01
Dibenzofuran	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Fluoranthene	2.89E+01	1.45E+01	5.52E+01	2.76E+01	2.07E+01	2.07E+00	4.42E+00	4.42E-01	5.75E+00	5.75E-01	1.01E+01	1.01E+00	1.08E+01	5.40E+00	1.57E+01	7.85E+00
Fluorene	3.18E+00	1.59E+00	6.07E+00	3.03E+00	2.28E+00	2.28E-01	4.85E-01	4.85E-02	6.32E-01	6.32E-02	1.11E+00	1.11E-01	1.19E+00	5.93E-01	1.73E+00	8.63E-01
Indeno(1,2,3-cd)pyrene	7.40E+00	3.70E+00	1.41E+01	7.06E+00	5.30E+00	5.30E-01	1.13E+00	1.13E-01	1.47E+00	1.47E-01	2.59E+00	2.59E-01	2.76E+00	1.38E+00	4.02E+00	2.01E+00
Methylnaphthalene,2-	5.84E-01	2.92E-01	1.12E+00	5.58E-01	4.19E-01	4.19E-02	8.92E-02	8.92E-03	1.16E-01	1.16E-02	2.04E-01	2.04E-02	2.18E-01	1.09E-01	3.17E-01	1.59E-01
Naphthalene	1.05E+00	5.24E-01	2.00E+00	1.00E+00	7.51E-01	7.51E-02	1.60E-01	1.60E-02	2.08E-01	2.08E-02	3.66E-01	3.66E-02	3.91E-01	1.96E-01	5.69E-01	2.85E-01
Phenanthrene	2.98E+01	1.49E+01	5.70E+01	2.85E+01	2.14E+01	2.14E+00	4.56E+00	4.56E-01	5.94E+00	5.94E-01	1.04E+01	1.04E+00	1.11E+01	5.57E+00	1.62E+01	8.11E+00
Pyrene	2.45E+01	1.22E+01	4.67E+01	2.33E+01	1.75E+01	1.75E+00	3.73E+00	3.73E-01	4.86E+00	4.86E-01	8.55E+00	8.55E-01	9.13E+00	4.56E+00	1.33E+01	6.64E+00
Aluminum	1.88E+03	1.88E+02	3.58E+03	3.58E+02	1.82E+02	1.82E+01	3.88E+01	3.88E+00	5.05E+01	5.05E+00	8.88E+01	8.88E+00	7.00E+02	7.00E+01	1.02E+03	1.02E+02
Beryllium	6.50E-01	6.50E-02	1.24E+00	1.24E-01	NA	NA	NA	NA	NA	NA	NA	NA	2.43E-01	2.43E-02	3.53E-01	3.53E-02
Chromium	2.29E+02	2.29E+01	4.38E+02	4.38E+01	3.16E+02	3.16E+01	6.73E+01	6.73E+00	8.78E+01	8.78E-01	1.54E+02	1.54E+00	8.56E+01	8.56E+00	1.25E+02	1.25E+01
Copper	3.91E+00	3.91E-01	7.46E+00	7.46E-01	9.17E+01	9.17E+00	1.95E+01	1.95E+00	2.54E+01	2.54E+00	4.47E+01	4.47E+00	1.46E+00	1.46E-01	2.12E+00	2.12E-01
Iron	5.76E+01	5.76E+00	1.10E+02	1.10E+01	1.59E+02	1.59E+01	3.38E+01	3.38E+00	4.41E+01	4.41E+00	7.75E+01	7.75E+00	2.15E+01	2.15E+00	3.13E+01	3.13E+00
Lead	1.42E+02	1.42E+01	2.71E+02	2.71E+01	3.91E+02	3.91E+01	8.33E+01	8.33E+00	1.09E+02	1.09E+01	1.91E+02	1.91E+01	5.30E+01	5.30E+00	7.71E+01	7.71E+00
Manganese	6.44E+00	6.44E-01	1.23E+01	1.23E+00	3.13E+00	3.13E-01	6.67E-01	6.67E-02	8.69E-01	8.69E-02	1.53E+00	1.53E-01	2.40E+00	2.40E-01	3.50E+00	3.50E-01
Mercury	1.08E+00	1.08E-01	2.05E+00	2.05E-01	2.96E+01	2.96E+00	6.31E+00	6.31E-01	6.86E+00	6.86E-01	1.21E+01	1.21E+00	2.01E+00	2.01E-01	5.84E-01	5.84E-02
Nickel	1.23E-01	1.23E-02	2.35E-01	2.35E-02	NA	NA	NA	NA	NA	NA	NA	NA	4.60E-02	4.60E-03	6.70E-02	6.70E-03
Vanadium	2.54E+02	2.54E+01	4.86E+02	4.86E+01	2.47E+01	2.47E+00	5.26E+00	5.25E-01	6.84E+00	6.84E-01	1.20E+01	1.20E+00	9.50E+01	9.50E+00	1.38E+02	1.38E+01
Zinc	2.58E+00	2.58E-01	4.93E+00	4.93E-01	2.56E+01	2.56E+00	5.45E+00	5.45E-01	7.10E+00	7.10E-01	1.25E+01	1.25E+00	9.63E-01	9.63E-02	1.40E+00	1.40E-01

NA - Not Available

TABLE 7-27

TERRESTRIAL SPECIES - LESS CONSERVATIVE INPUTS
MAXIMUM CONCENTRATION HAZARD QUOTIENT VALUES
SITE 3 - SOIL AREA OF CONCERN
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Ecological Contaminants of Concern	Vole		Shrew		Robin		Hawk		Woodcock		Wren		Fox		Mouse	
	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l
Acenaphthene	4.61E+00	2.30E+00	8.48E+00	4.24E+00	2.82E+00	2.82E-01	1.83E-01	1.83E-02	1.53E+00	1.53E-01	4.02E-01	4.02E-02	9.11E-01	4.56E-01	2.75E+00	1.38E+00
Anthracene	1.20E+01	6.02E+00	2.21E+01	1.11E+01	7.36E+00	7.36E-01	4.77E-01	4.77E-02	4.00E+00	4.00E-01	1.05E+00	1.05E-01	2.38E+00	1.19E+00	7.19E+00	3.60E+00
Benzo(a)anthracene	2.36E+01	1.18E+01	4.34E+01	2.17E+01	1.44E+01	1.44E+00	9.33E-01	9.33E-02	7.82E+00	7.82E-01	2.06E+00	2.06E-01	4.66E+00	2.33E+00	1.41E+01	7.04E+00
Benzo(a)pyrene	1.97E+01	9.86E+00	3.63E+01	1.81E+01	1.21E+01	1.21E+00	7.81E-01	7.81E-02	6.55E+00	6.55E-01	1.72E+00	1.72E-01	3.90E+00	1.95E+00	1.18E+01	5.89E+00
Benzo(b)fluoranthene	2.51E+01	1.25E+01	4.62E+01	2.31E+01	1.54E+01	1.54E+00	9.94E-01	9.94E-02	8.33E+00	8.33E-01	2.19E+00	2.19E-01	4.96E+00	2.48E+00	1.50E+01	7.50E+00
Benzo(g,h,i)perylene	1.05E+01	5.25E+00	1.93E+01	9.66E+00	6.42E+00	6.42E-01	4.16E-01	4.16E-02	3.49E+00	3.49E-01	9.17E-01	9.17E-02	2.08E+00	1.04E+00	6.27E+00	3.14E+00
Benzo(k)fluoranthene	8.19E+00	4.10E+00	1.51E+01	7.54E+00	5.01E+00	5.01E-01	3.25E-01	3.25E-02	2.72E+00	2.72E-01	7.16E-01	7.16E-02	1.62E+00	8.10E-01	4.90E+00	2.45E+00
Carbazole	9.47E+00	4.74E+00	1.74E+01	8.72E+00	5.80E+00	5.80E-01	3.75E-01	3.75E-02	3.15E+00	3.15E-01	8.27E-01	8.27E-02	1.87E+00	9.36E-01	5.66E+00	2.83E+00
Chrysene	2.23E+01	1.11E+01	4.10E+01	2.05E+01	1.36E+01	1.36E+00	8.82E-01	8.82E-02	7.40E+00	7.40E-01	1.95E+00	1.95E-01	4.40E+00	2.20E+00	1.33E+01	6.66E+00
Dibenzo(a,h)anthracene	1.05E+01	5.25E+00	1.93E+01	9.66E+00	6.42E+00	6.42E-01	4.16E-01	4.16E-02	3.49E+00	3.49E-01	9.17E-01	9.17E-02	2.08E+00	1.04E+00	6.27E+00	3.14E+00
Dibenzofuran	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Fluoranthene	4.86E+01	2.43E+01	8.95E+01	4.48E+01	2.98E+01	2.98E+00	1.93E+00	1.93E-01	1.62E+01	1.62E+00	4.25E+00	4.25E-01	9.62E+00	4.81E+00	2.91E+01	1.45E+01
Fluorene	5.63E+00	2.82E+00	1.04E+01	5.18E+00	3.45E+00	3.45E-01	2.23E-01	2.23E-02	1.87E+00	1.87E-01	4.92E-01	4.92E-02	1.11E+00	5.57E-01	3.37E+00	1.68E+00
Indeno(1,2,3-cd)pyrene	1.20E+01	6.02E+00	2.21E+01	1.11E+01	7.36E+00	7.36E-01	4.77E-01	4.77E-02	4.00E+00	4.00E-01	1.05E+00	1.05E-01	2.38E+00	1.19E+00	7.19E+00	3.60E+00
Methylnaphthalene,2-	1.02E+00	5.12E-01	1.88E+00	9.42E-01	6.27E-01	6.27E-02	4.06E-02	4.06E-03	3.40E-01	3.40E-02	8.94E-02	8.94E-03	2.02E-01	1.01E-01	6.12E-01	3.06E-01
Naphthalene	1.87E+00	9.34E-01	3.44E+00	1.72E+00	1.14E+00	1.14E-01	7.40E-02	7.40E-03	6.21E-01	6.21E-02	1.63E-01	1.63E-02	3.69E-01	1.85E-01	1.12E+00	5.58E-01
Phenanthrene	5.12E+01	2.56E+01	9.42E+01	4.71E+01	3.13E+01	3.13E+00	2.03E+00	2.03E-01	1.70E+01	1.70E+00	4.47E+00	4.47E-01	1.01E+01	5.06E+00	3.06E+01	1.53E+01
Pyrene	4.10E+01	2.05E+01	7.54E+01	3.77E+01	2.51E+01	2.51E+00	1.62E+00	1.62E-01	1.36E+01	1.36E+00	3.58E+00	3.58E-01	8.10E+00	4.05E+00	2.45E+01	1.22E+01
Aluminum	1.74E+03	1.74E+02	3.21E+03	3.21E+02	1.44E+02	1.44E+01	9.34E+00	9.34E-01	7.83E+01	7.83E+00	2.06E+01	2.06E+00	3.44E+02	3.44E+01	1.04E+03	1.04E+02
Beryllium	6.04E-01	6.04E-02	1.11E+00	1.11E-01	NA	NA	NA	NA	NA	NA	NA	NA	1.19E-01	1.19E-02	3.61E-01	3.61E-02
Chromium	2.13E+02	2.13E+01	3.92E+02	3.92E+01	2.51E+02	2.51E+01	1.62E+01	1.62E+00	1.36E+02	1.36E+00	3.58E+01	3.58E-01	4.21E+01	4.21E+00	1.27E+02	1.27E+01
Copper	3.63E+00	3.63E-01	6.68E+00	6.68E-01	7.27E+01	7.27E+00	4.71E+00	4.71E-01	3.94E+01	3.94E+00	1.04E+01	1.04E+00	7.18E-01	7.18E-02	2.17E+00	2.17E-01
Iron	5.35E+01	5.35E+00	9.85E+01	9.85E+00	1.26E+02	1.26E+01	8.16E+00	8.16E-01	6.83E+01	6.83E+00	1.80E+01	1.80E+00	1.06E+01	1.06E+00	3.20E+01	3.20E+00
Lead	1.32E+02	1.32E+01	2.43E+02	2.43E+01	3.10E+02	3.10E+01	2.01E+01	2.01E+00	1.68E+02	1.68E+01	4.43E+01	4.43E+00	2.61E+01	2.61E+00	7.88E+01	7.88E+00
Manganese	5.98E+00	5.98E-01	1.10E+01	1.10E+00	2.48E+00	2.48E-01	1.61E-01	1.61E-02	1.35E+00	1.35E-01	3.54E-01	3.54E-02	1.18E+00	1.18E-01	3.57E+00	3.57E-01
Mercury	9.98E-01	9.98E-02	1.84E+00	1.84E-01	2.35E+01	2.35E+00	1.52E+00	1.52E-01	1.06E+01	1.06E+00	2.80E+00	2.80E-01	9.87E-01	9.87E-02	5.97E-01	5.97E-02
Nickel	1.14E-01	1.14E-02	2.11E-01	2.11E-02	NA	NA	NA	NA	NA	NA	NA	NA	2.26E-02	2.26E-03	6.84E-02	6.84E-03
Vanadium	2.36E+02	2.36E+01	4.35E+02	4.35E+01	1.95E+01	1.95E+00	1.27E+00	1.27E-01	1.06E+01	1.06E+00	2.79E+00	2.79E-01	4.67E+01	4.67E+00	1.41E+02	1.41E+01
Zinc	2.40E+00	2.40E-01	4.41E+00	4.41E-01	2.03E+01	2.03E+00	1.31E+00	1.31E-01	1.10E+01	1.10E+00	2.90E+00	2.90E-01	4.74E-01	4.74E-02	1.43E+00	1.43E-01

NA - Not Available

TABLE 7-28

TERRESTRIAL SPECIES - LESS CONSERVATIVE INPUTS
MEAN CONCENTRATION HAZARD QUOTIENT VALUES
SITE 3 - SOIL AREA OF CONCERN
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Ecological Contaminants of Concern	Vole		Shrew		Robin		Hawk		Woodcock		Wren		Fox		Mouse	
	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l
Acenaphthene	2.43E+00	1.22E+00	4.47E+00	2.24E+00	1.49E+00	1.49E-01	9.63E-02	9.63E-03	8.07E-01	8.07E-02	2.12E-01	2.12E-02	4.80E-01	2.40E-01	1.45E+00	7.26E-01
Anthracene	6.68E+00	3.34E+00	1.23E+01	6.15E+00	4.09E+00	4.09E-01	2.65E-01	2.65E-02	2.22E+00	2.22E-01	5.84E-01	5.84E-02	1.32E+00	6.61E-01	3.99E+00	2.00E+00
Benzo(a)anthracene	1.30E+01	6.52E+00	2.40E+01	1.20E+01	7.98E+00	7.98E-01	5.17E-01	5.17E-02	4.33E+00	4.33E-01	1.14E+00	1.14E-01	2.58E+00	1.29E+00	7.79E+00	3.90E+00
Benzo(a)pyrene	1.14E+01	5.68E+00	2.09E+01	1.05E+01	6.95E+00	6.95E-01	4.50E-01	4.50E-02	3.77E+00	3.77E-01	9.92E-01	9.92E-02	2.25E+00	1.12E+00	6.79E+00	3.39E+00
Benzo(b)fluoranthene	1.44E+01	7.18E+00	2.65E+01	1.32E+01	8.79E+00	8.79E-01	5.69E-01	5.69E-02	4.77E+00	4.77E-01	1.26E+00	1.26E-01	2.84E+00	1.42E+00	8.59E+00	4.29E+00
Benzo(g,h,i)perylene	6.12E+00	3.06E+00	1.13E+01	5.63E+00	3.75E+00	3.75E-01	2.42E-01	2.42E-02	2.03E+00	2.03E-01	5.35E-01	5.35E-02	1.21E+00	6.05E-01	3.66E+00	1.83E+00
Benzo(k)fluoranthene	4.37E+00	2.18E+00	8.04E+00	4.02E+00	2.67E+00	2.67E-01	1.73E-01	1.73E-02	1.45E+00	1.45E-01	3.81E-01	3.81E-02	8.63E-01	4.32E-01	2.61E+00	1.30E+00
Carbazole	5.15E+00	2.57E+00	9.48E+00	4.74E+00	3.15E+00	3.15E-01	2.04E-01	2.04E-02	1.71E+00	1.71E-01	4.50E-01	4.50E-02	1.02E+00	5.09E-01	3.08E+00	1.54E+00
Chrysene	1.27E+01	6.36E+00	2.34E+01	1.17E+01	7.78E+00	7.78E-01	5.04E-01	5.04E-02	4.22E+00	4.22E-01	1.11E+00	1.11E-01	2.51E+00	1.26E+00	7.60E+00	3.80E+00
Dibenzo(a,h)anthracene	1.64E+00	8.19E-01	3.02E+00	1.51E+00	1.00E+00	1.00E-01	6.49E-02	6.49E-03	5.44E-01	5.44E-02	1.43E-01	1.43E-02	3.24E-01	1.62E-01	9.79E-01	4.90E-01
Dibenzofuran	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Fluoranthene	2.69E+01	1.34E+01	4.94E+01	2.47E+01	1.64E+01	1.64E+00	1.06E+00	1.06E-01	8.92E+00	8.92E-01	2.35E+00	2.35E-01	5.31E+00	2.65E+00	1.60E+01	8.02E+00
Fluorene	2.95E+00	1.48E+00	5.43E+00	2.72E+00	1.81E+00	1.81E-01	1.17E-01	1.17E-02	9.80E-01	9.80E-02	2.58E-01	2.58E-02	5.83E-01	2.92E-01	1.76E+00	8.82E-01
Indeno(1,2,3-cd)pyrene	6.87E+00	3.43E+00	1.26E+01	6.32E+00	4.20E+00	4.20E-01	2.72E-01	2.72E-02	2.28E+00	2.28E-01	6.00E-01	6.00E-02	1.36E+00	6.79E-01	4.11E+00	2.05E+00
Methylnaphthalene,2-	5.42E-01	2.71E-01	9.98E-01	4.99E-01	3.32E-01	3.32E-02	2.15E-02	2.15E-03	1.80E-01	1.80E-02	4.74E-02	4.74E-03	1.07E-01	5.36E-02	3.24E-01	1.62E-01
Naphthalene	9.73E-01	4.86E-01	1.79E+00	8.95E-01	5.95E-01	5.95E-02	3.85E-02	3.85E-03	3.23E-01	3.23E-02	8.50E-02	8.50E-03	1.92E-01	9.62E-02	5.81E-01	2.91E-01
Phenanthrene	2.77E+01	1.39E+01	5.10E+01	2.55E+01	1.70E+01	1.70E+00	1.10E+00	1.10E-01	9.20E+00	9.20E-01	2.42E+00	2.42E-01	5.48E+00	2.74E+00	1.66E+01	8.28E+00
Pyrene	2.27E+01	1.14E+01	4.18E+01	2.09E+01	1.39E+01	1.39E+00	8.99E-01	8.99E-02	7.54E+00	7.54E-01	1.98E+00	1.98E-01	4.49E+00	2.24E+00	1.36E+01	6.78E+00
Aluminum	1.74E+03	1.74E+02	3.21E+03	3.21E+02	1.44E+02	1.44E+01	9.34E+00	9.34E-01	7.83E+01	7.83E+00	2.06E+01	2.06E+00	3.44E+02	3.44E+01	1.04E+03	1.04E+02
Beryllium	6.04E-01	6.04E-02	1.11E+00	1.11E-01	NA	NA	NA	NA	NA	NA	NA	NA	1.19E-01	1.19E-02	3.61E-01	3.61E-02
Chromium	2.13E+02	2.13E+01	3.92E+02	3.92E+01	2.51E+02	2.51E+01	1.62E+01	1.62E+00	1.36E+02	1.36E+00	3.58E+01	3.58E-01	4.21E+01	4.21E+00	1.27E+02	1.27E+01
Copper	3.63E+00	3.63E-01	6.68E+00	6.68E-01	7.27E+01	7.27E+00	4.71E+00	4.71E-01	3.94E+01	3.94E+00	1.04E+01	1.04E+00	7.18E-01	7.18E-02	2.17E+00	2.17E-01
Iron	5.35E+01	5.35E+00	9.85E+01	9.85E+00	1.26E+02	1.26E+01	8.15E+00	8.15E-01	6.83E+01	6.83E+00	1.80E+01	1.80E+00	1.06E+01	1.06E+00	3.20E+01	3.20E+00
Lead	1.32E+02	1.32E+01	2.43E+02	2.43E+01	3.10E+02	3.10E+01	2.01E+01	2.01E+00	1.68E+02	1.68E+01	4.43E+01	4.43E+00	2.61E+01	2.61E+00	7.88E+01	7.88E+00
Manganese	5.98E+00	5.98E-01	1.10E+01	1.10E+00	2.48E+00	2.48E-01	1.61E-01	1.61E-02	1.35E+00	1.35E-01	3.54E-01	3.54E-02	1.18E+00	1.18E-01	3.57E+00	3.57E-01
Mercury	9.98E-01	9.98E-02	1.84E+00	1.84E-01	2.35E+01	2.35E+00	1.52E+00	1.52E-01	1.06E+01	1.06E+00	2.80E+00	2.80E-01	9.87E-01	9.87E-02	5.97E-01	5.97E-02
Nickel	1.14E-01	1.14E-02	2.11E-01	2.11E-02	NA	NA	NA	NA	NA	NA	NA	NA	2.26E-02	2.26E-03	6.84E-02	6.84E-03
Vanadium	2.36E+02	2.36E+01	4.35E+02	4.35E+01	1.95E+01	1.95E+00	1.27E+00	1.27E-01	1.06E+01	1.06E+00	2.79E+00	2.79E-01	4.67E+01	4.67E+00	1.41E+02	1.41E+01
Zinc	2.40E+00	2.40E-01	4.41E+00	4.41E-01	2.03E+01	2.03E+00	1.31E+00	1.31E-01	1.10E+01	1.10E+00	2.90E+00	2.90E-01	4.74E-01	4.74E-02	1.43E+00	1.43E-01

NA - Not Available

TABLE 7-29

TERRESTRIAL SPECIES - HAZARD QUOTIENT VALUES SUMMARY
SITE 3 - SOIL AREA OF CONCERN
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Receptor	Most Conservative			Least Conservative			Least Cons. Risk Drivers Above Background
	HQ>100	100>HQ>10	10>HQ>1	HQ>100	100>HQ>10	10>HQ>1	
Vole	Aluminum Chromium Lead Vanadium	12 PAHs Iron	5 PAHs Copper Manganese Mercury Zinc	Aluminum	3 PAHs Chromium Lead Vanadium	11 PAHs Iron	PAHs Aluminum Copper* Iron Lead Manganese Mercury Vanadium Zinc
Shrew	2 PAHs Aluminum Chromium Iron Lead Vanadium	12 PAHs Manganese	3 PAHs Beryllium Copper Mercury Zinc	Aluminum	7 PAHs Chromium Lead Vanadium	8 PAHs Iron Manganese	
Robin	Aluminum Chromium Iron Lead	7 PAHs Copper Mercury Vanadium Zinc	9 PAHs Manganese		Aluminum Chromium Iron Lead	3 PAHs Copper Mercury Vanadium Zinc	
Hawk		Aluminum Chromium Copper Iron Lead	13 PAHs Mercury Vanadium Zinc			Chromium Lead	
Woodcock	Lead	2 PAHs Aluminum Chromium Copper Iron	12 PAHs Mercury Vanadium Zinc		Lead	Aluminum Chromium Copper Iron Mercury Vanadium Zinc	
Wren	Chromium Lead	3 PAHs Aluminum Copper Iron Mercury Vanadium Zinc	12 PAHs Manganese			Aluminum Copper Iron Lead	
Fox	Aluminum	4 PAHs Chromium Iron Lead Vanadium	11 PAHs Copper Manganese Mercury		Aluminum	7 PAHs Chromium Iron Lead Vanadium	
Mouse	Aluminum Chromium Vanadium	7 PAHs Iron Lead	9 PAHs Copper Manganese Zinc	Aluminum Chromium	Vanadium	12 PAHs Iron Lead	

Notes:

HQ Hazard Quotient
ECOC Ecological Contaminant of Concern
* Concentrations were below surface soil screening levels, but constituent included in the models as a surface water ECOC

TABLE 7-30

COMPARISON OF BENCHMARK VALUES TO SURFACE WATER CONCENTRATIONS
SITES 1 AND 3
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Ecological Contaminant of Concern	Maximum Concentration	No. of Positive Detects/No. of Samples	Benchmark	Reference	Hazard Quotient	Normal 95% UCL Off-Station Tidal Freshwater Background
Inorganics (µg/L)						
Aluminum	2,420	4/4	NE	NA	NA	2,677
Copper	9.1K	4/4	2.4	a-aquatifc life	3.79	4.01
Iron	3,250J	4/4	NE	NA	NA	3,983
Manganese	54.9J	4/4	NE	NA	NA	254
Zinc	20.1K	4/4	81	a-aquatifc life	0.25	10.95

Notes:

Highlighted areas represent hazard quotients greater than one.

a - USEPA, 1987 (saltwater dissolved chronic ambient water quality criteria)

J Analyte was positively identified, value is estimated
K Estimated value, biased high
UCL Upper Confidence Level
µg/L micrograms per liter

TABLE 7-31

COMPARISON OF BENCHMARK VALUES TO SEDIMENT CONCENTRATIONS
SITES 1 AND 3
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Ecological Contaminant of Concern	Maximum Concentration	No. of Positive Detects/ No. of Samples	Benchmark	Reference	Hazard Quotient	Normal 95% UCL Tidal Freshwater Stream Background
Inorganics (mg/kg)						
Aluminum	21,100	10/10	NE	NA	NA	23,398
Arsenic	15.4J	8/10	70	a-ER-M	0.22	8.70
Cadmium	1.7	1/10	0.6	b-NOAEL	1.67	ND
Cobalt	8.9	7/10	NE	NA	NA	9.86
Iron	39,100	10/10	27,000	c-AET	1.45	34,425
Lead	56.8	10/10	218	a-ER-M	0.26	29.34
Manganese	379	10/10	230	c-AET	1.65	532
Nickel	21	6/10	51.6	a-ER-M	0.41	28.02
Vanadium	51.8	10/10	NE	NA	NA	51.30

Notes:

Highlighted areas represent hazard quotients greater than one.

a - Long et al., 1995
b - Wentsel, et al., 1977
c - Tetra Tech, 1989

J	Analyte was positively identified, value is estimated
NA	Not Applicable
ND	Not Detected
NE	Not Established
UCL	Upper Confidence Level
ER-M	Effects Range - Median
NOAEL	No Observed Adverse Effect Level
AET	Apparent Effect Threshold

TABLE 7-32

AQUATIC SPECIES - CONSERVATIVE INPUTS
MAXIMUM CONCENTRATION HAZARD QUOTIENT VALUES
SITES 1 AND 3
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Ecological Contaminant of Concern	Frog		Heron		Bass	
	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l
Aluminum	NA	NA	5.64E+01	5.64E+00	NA	NA
Arsenic	NA	NA	1.37E+01	1.37E+00	NA	NA
Cadmium	NA	NA	1.51E+00	1.51E-01	NA	NA
Cobalt	NA	NA	2.61E+00	2.61E-01	NA	NA
Copper	NA	NA	3.33E+01	3.33E+00	NA	NA
Iron	NA	NA	1.15E+02	1.15E+01	NA	NA
Lead	NA	NA	5.56E+01	5.56E+00	NA	NA
Manganese	NA	NA	1.12E-01	1.12E-02	NA	NA
Nickel	NA	NA	NA	NA	NA	NA
Vanadium	NA	NA	1.34E+00	1.34E-01	NA	NA
Zinc	2.74E-01	2.74E-02	2.85E+00	2.85E-01	NA	NA

NA - Not Available

TABLE 7-33

AQUATIC SPECIES - CONSERVATIVE INPUTS
MEAN CONCENTRATION HAZARD QUOTIENT VALUES
SITES 1 AND 3
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

	Frog		Heron		Bass	
	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
of Concern	HQ_n	HQ_l	HQ_n	HQ_l	HQ_n	HQ_l
Aluminum	NA	NA	2.92E+01	2.92E+00	NA	NA
Arsenic	NA	NA	6.12E+00	6.12E-01	NA	NA
Cadmium	NA	NA	7.55E-01	7.55E-02	NA	NA
Cobalt	NA	NA	1.36E+00	1.36E-01	NA	NA
Copper	NA	NA	1.82E+01	1.82E+00	NA	NA
Iron	NA	NA	6.69E+01	6.69E+00	NA	NA
Lead	NA	NA	1.94E+01	1.94E+00	NA	NA
Manganese	NA	NA	5.04E-02	5.04E-03	NA	NA
Nickel	NA	NA	NA	NA	NA	NA
Vanadium	NA	NA	7.34E-01	7.34E-02	NA	NA
Zinc	1.42E-01	1.42E-02	1.48E+00	1.48E-01	NA	NA

NA - Not Available

TABLE 7-34

AQUATIC SPECIES - LESS CONSERVATIVE INPUTS
MAXIMUM CONCENTRATION HAZARD QUOTIENT VALUES
SITES 1 AND 3
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Ecological Contaminants of Concern	Frog		Heron		Bass	
	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l
Aluminum	NA	NA	3.77E+01	3.77E+00	NA	NA
Arsenic	NA	NA	9.14E+00	9.14E-01	NA	NA
Cadmium	NA	NA	1.01E+00	1.01E-01	NA	NA
Cobalt	NA	NA	1.74E+00	1.74E-01	NA	NA
Copper	NA	NA	2.23E+01	2.23E+00	NA	NA
Iron	NA	NA	7.66E+01	7.66E+00	NA	NA
Lead	NA	NA	3.71E+01	3.71E+00	NA	NA
Manganese	NA	NA	7.45E-02	7.45E-03	NA	NA
Nickel	NA	NA	NA	NA	NA	NA
Vanadium	NA	NA	8.92E-01	8.92E-02	NA	NA
Zinc	1.96E-01	1.96E-02	1.90E+00	1.90E-01	NA	NA

NA - Not Available

TABLE 7-35

AQUATIC SPECIES - LESS CONSERVATIVE INPUTS
MEAN CONCENTRATION HAZARD QUOTIENT VALUES
SITES 1 AND 3
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Ecological Contaminants of Concern	Frog		Heron		Bass	
	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l
Aluminum	NA	NA	1.95E+01	1.95E+00	NA	NA
Arsenic	NA	NA	4.08E+00	4.08E-01	NA	NA
Cadmium	NA	NA	5.04E-01	5.04E-02	NA	NA
Cobalt	NA	NA	9.09E-01	9.09E-02	NA	NA
Copper	NA	NA	1.22E+01	1.22E+00	NA	NA
Iron	NA	NA	4.47E+01	4.47E+00	NA	NA
Lead	NA	NA	1.30E+01	1.30E+00	NA	NA
Manganese	NA	NA	3.36E-02	3.36E-03	NA	NA
Nickel	NA	NA	NA	NA	NA	NA
Vanadium	NA	NA	4.90E-01	4.90E-02	NA	NA
Zinc	1.02E-01	1.02E-02	9.85E-01	9.85E-02	NA	NA

NA - Not Available

TABLE 7-36

AQUATIC SPECIES - HAZARD QUOTIENT VALUES SUMMARY
SITES 1 AND 3
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

	Most Conservative			Least Conservative			Least Cons. Risk Drivers Above Background
Receptor	HQ>100	100>HQ>10	10>HQ>1	HQ>100	100>HQ>10	10>HQ>1	
Frog							Copper* Iron Lead
Heron	Iron	Aluminum Arsenic Copper Lead	Cadmium Cobalt Vanadium Zinc			Aluminum Copper Iron Lead	
Bass							

Notes:

HQ Hazard Quotient
ECOC Ecological Contaminant of Concern
* Concentrations were below sediment screening levels, but constituent included in the models as a surface water ECOC

FIGURES

318735WP

LOCATION	1SS07
DATE SAMPLED	01/24/96
DEPTH	0–0.5'
TOTAL INORGANICS (mg/kg)	
LEAD	9.9

LOCATION	1SS07D
DATE SAMPLED	01/24/96
DEPTH	0–0.5'
TOTAL INORGANICS (mg/kg)	
LEAD	9.4

LOCATION	1SS13
DATE SAMPLED	01/23/96
DEPTH	0–0.5'
TOTAL INORGANICS (mg/kg)	
LEAD	18.6

LOCATION	1SS17
DATE SAMPLED	01/23/96
DEPTH	0–0.5'
TOTAL INORGANICS (mg/kg)	
LEAD	12

LOCATION	3SS13
DATE SAMPLED	01/27/96
DEPTH	0–0.5'
TOTAL INORGANICS (mg/kg)	
CHROMIUM	20.7 K
LEAD	12.4

LOCATION	3SB15A-00
DATE SAMPLED	01/29/96
DEPTH	0–0.5'
TOTAL INORGANICS (mg/kg)	
LEAD	74.3

LOCATION	3SS11
DATE SAMPLED	01/30/96
DEPTH	0–0.5'
TOTAL INORGANICS (mg/kg)	
ANTIMONY	4.6 L
LEAD	28.1

LOCATION	3SS11D
DATE SAMPLED	01/30/96
DEPTH	0–0.5'
TOTAL INORGANICS (mg/kg)	
ANTIMONY	16.8 L
LEAD	30.6

LOCATION	3SB08A-00
DATE SAMPLED	02/08/96
DEPTH	0–0.5'
TOTAL INORGANICS (mg/kg)	
LEAD	79.3

LOCATION	3SS12
DATE SAMPLED	01/27/96
DEPTH	0–0.5'
TOTAL INORGANICS (mg/kg)	
CHROMIUM	31.6 K
LEAD	14.7
VANADIUM	37.7

LOCATION	3SS08
DATE SAMPLED	01/26/96
DEPTH	0–0.5'
TOTAL INORGANICS (mg/kg)	
LEAD	14.9

LOCATION	3SS05
DATE SAMPLED	01/26/96
DEPTH	0–0.5'
TOTAL INORGANICS (mg/kg)	
CHROMIUM	22.1
LEAD	10.9

SITE 1

SITE 3

SOIL AOC (SEE FIGURE 7-2)

WOODS

POND

DIRT ROAD

DIRT MOUND

DEBRIS AREA

EDGE OF WATER

INDIAN FIELD CREEK

MAG. BLDG. 266

MAG. BLDG. 267

GATE

1GW13A, 1SS07, 1SS09, 1SS08, 1SS10, 1SS13, 1SS16, 1SS17, 1SS12, 1SS15, 1SS18, 1GW19, 1GW18, 1SS14, 1GW12A, 1SS11, 1GW21, 1GW20

3SS11, 3GW19A, 3GW08A, 3GW07, 3SS14, 3SS13, 3GW15A, 3SS12, 3SS09, 3SS05, 3SS08, 3SS07, 3GW06, 3SS06, 3SS04

180 0 90 180

1 inch = 180 ft.

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LEGEND

- EDGE OF WATER
- TREELINE
- EDGE OF PAVEMENT
- BUILDING
- WETLANDS
- DEBRIS AREA
- REMEDIAL INVESTIGATION SITE
- 3SS04 – SURFACE SOIL SAMPLE LOCATION
- 1GW11 – MONITORING WELL/SOIL BORING LOCATION
- UCL – UPPER CONFIDENCE LEVEL

NOTE: ONLY CONCENTRATIONS GREATER THAN BACKGROUND ARE PRESENTED.

SOURCE: PHR & A, AUGUST 1995.

FIGURE 7-1
ECOLOGICAL RECEPTOR RISK DRIVERS DETECTED IN SURFACE SOIL ABOVE BACKGROUND UCL CONCENTRATIONS SITE 1 AND SITE 3 PROPER
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

00998 DB8Y

LOCATION	3SS10E
DATE SAMPLED	08/26/96
DEPTH	0–0.5'
SEMIVOLATILES (ug/kg)	
PHENANTHRENE	250 J
ANTHRACENE	87 J
CARBAZOLE	43 J
FLUORANTHENE	370 J
PYRENE	290 J
BENZO(A)ANTHRACENE	160 J
CHRYSENE	230 J
BENZO(B)FLUORANTHENE	120 J
BENZO(K)FLUORANTHENE	200 J
BENZO(A)PYRENE	170 J
INDENO(1,2,3–CD)PYRENE	120 J
BENZO(G,H,I)PERYLENE	110 J

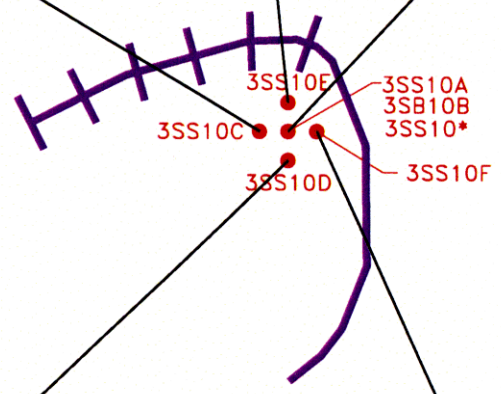
LOCATION	3SS10C
DATE SAMPLED	08/26/96
DEPTH	0–0.5'
SEMIVOLATILES (ug/kg)	
ACENAPHTHENE	2,800
FLUORENE	3,000
PHENANTHRENE	49,000
ANTHRACENE	15,000
CARBAZOLE	9,500
FLUORANTHENE	56,000
PYRENE	49,000
BENZO(A)ANTHRACENE	28,000
CHRYSENE	33,000
BENZO(B)FLUORANTHENE	38,000
BENZO(K)FLUORANTHENE	5,400 J
BENZO(A)PYRENE	31,000
INDENO(1,2,3–CD)PYRENE	18,000
DIBENZO(A,H)ANTHRACENE	2,300
BENZO(G,H,I)PERYLENE	18,000

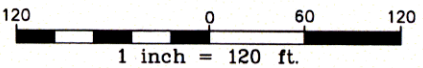
LOCATION	3SS10A
DATE SAMPLED	08/26/96
DEPTH	0–0.5"
SEMIVOLATILES (ug/kg)	
ACENAPHTHENE	440
FLUORENE	490
PHENANTHRENE	6,600
ANTHRACENE	1,500
CARBAZOLE	1,200
FLUORANTHENE	8,300
PYRENE	7,000
BENZO(A)ANTHRACENE	3,600
CHRYSENE	4,600
BENZO(B)FLUORANTHENE	5,300
BENZO(K)FLUORANTHENE	1,700
BENZO(A)PYRENE	4,000
INDENO(1,2,3–CD)PYRENE	1,800
DIBENZO(A,H)ANTHRACENE	280 J
BENZO(G,H,I)PERYLENE	1,400

LOCATION	3SS10*
DATE SAMPLED	01/27/96
DEPTH	0–0.5"
SEMIVOLATILES (ug/kg)	
ACENAPHTHENE	18,000
FLUORENE	22,000
PHENANTHRENE	200,000
ANTHRACENE	47,000
CARBAZOLE	37,000
FLUORANTHENE	190,000
PYRENE	160,000
BENZO(A)ANTHRACENE	92,000
CHRYSENE	87,000
BENZO(B)FLUORANTHENE	98,000
BENZO(K)FLUORANTHENE	32,000
BENZO(A)PYRENE	77,000
INDENO(1,2,3–CD)PYRENE	47,000
DIBENZO(A,H)ANTHRACENE	12,000
BENZO(G,H,I)PERYLENE	41,000
INORGANICS (mg/kg)	
LEAD	59.4
MANGANESE	1,580
MERCURY	0.15
VANADIUM	142
ZINC	180

LOCATION	3SS10D
DATE SAMPLED	08/26/96
DEPTH	0–0.5'
SEMIVOLATILES (ug/kg)	
PHENANTHRENE	310 J
ANTHRACENE	65 J
CARBAZOLE	63 J
FLUORANTHENE	390 J
PYRENE	340 J
BENZO(A)ANTHRACENE	190 J
CHRYSENE	230 J
BENZO(B)FLUORANTHENE	270 J
BENZO(K)FLUORANTHENE	130 J
BENZO(A)PYRENE	230 J
INDENO(1,2,3–CD)PYRENE	160 J
DIBENZO(A,H)ANTHRACENE	41 J
BENZO(G,H,I)PERYLENE	110 J

LOCATION	3SS10F
DATE SAMPLED	08/26/96
DEPTH	0–0.5'
SEMIVOLATILES (ug/kg)	
ACENAPHTHENE	260 J
FLUORENE	290 J
PHENANTHRENE	3,400
ANTHRACENE	810
CARBAZOLE	720
FLUORANTHENE	4,200
PYRENE	3,400
BENZO(A)ANTHRACENE	2,100
CHRYSENE	2,200
BENZO(B)FLUORANTHENE	2,400
BENZO(K)FLUORANTHENE	1,100
BENZO(A)PYRENE	1,900
INDENO(1,2,3–CD)PYRENE	1,400
DIBENZO(A,H)ANTHRACENE	270 J
BENZO(G,H,I)PERYLENE	970





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LEGEND

3SS10A ● – SURFACE SOIL SAMPLE (0–6" bgs)

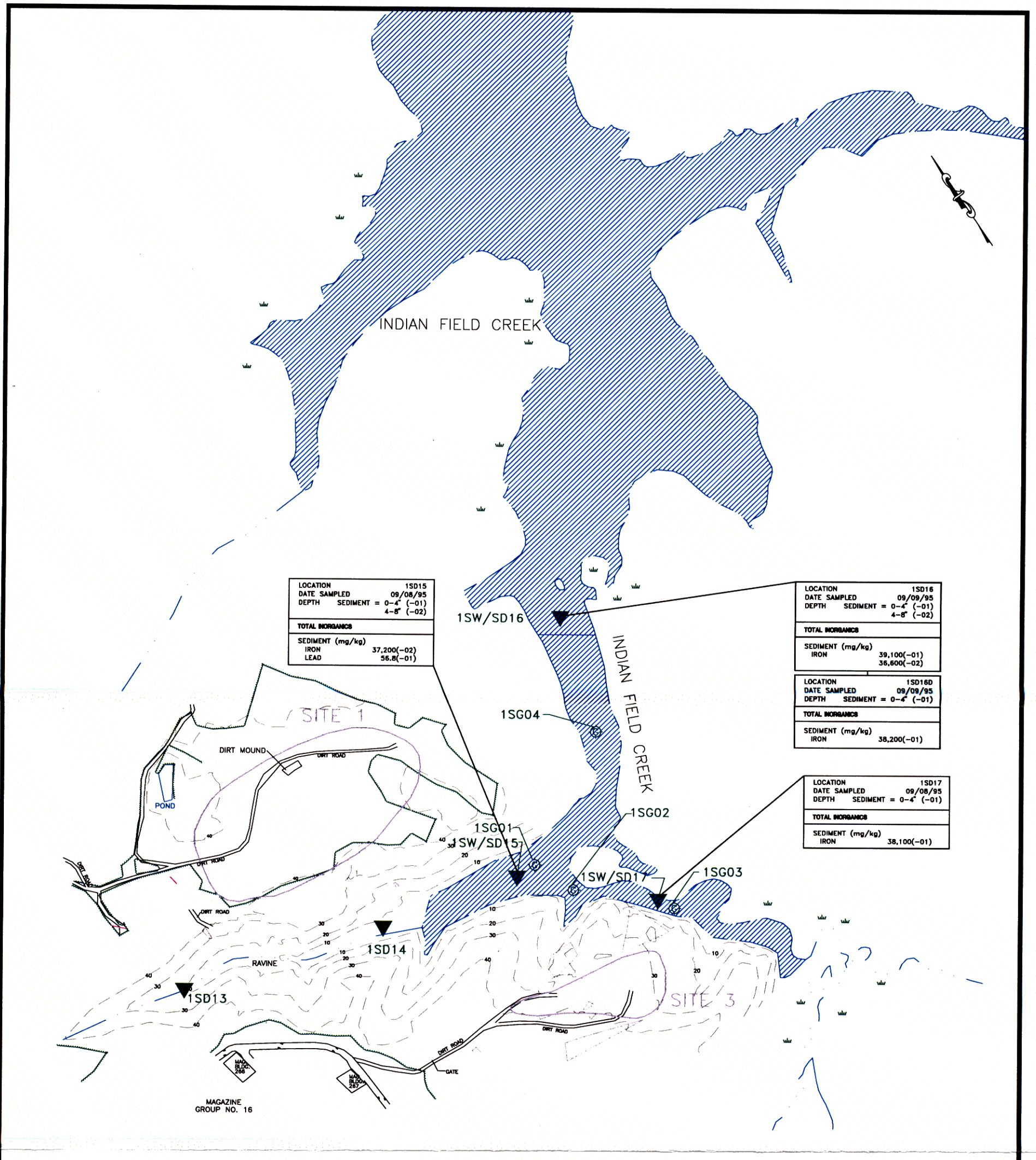
– REMEDIAL INVESTIGATION SITE

* – ORIGINAL SURFACE SOIL SAMPLE COLLECTED DURING THE ROUND TWO RI

UCL – UPPER CONFIDENCE LEVEL

SOURCE: PHR & A, AUGUST 1995.

FIGURE 7–2
ECOLOGICAL RECEPTOR RISK DRIVERS DETECTED IN SURFACE SOIL ABOVE BACKGROUND UCL CONCENTRATIONS
SITE 3 – SOIL AOC
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA



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LEGEND

- EDGE OF WATER
- TREELINE
- BUILDING
- WETLANDS
- DEBRIS AREA
- SUSPECTED SITE LIMIT

1SW/SD17 – ROUND TWO RI SURFACE WATER/SEDIMENT/ BENTHIC/FISH SURVEY LOCATION

1SG01 – STAFF GAUGE LOCATION

UCL – UPPER CONFIDENCE LEVEL

SOURCE: PHR & A, AUGUST 1995.

FIGURE 7-3
ECOLOGICAL RECEPTOR RISK DRIVERS DETECTED IN SEDIMENT ABOVE BACKGROUND UCL CONCENTRATIONS SITES 1 AND 3
NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA

8.0 SUMMARY AND CONCLUSIONS

The Round Two Remedial Investigation at Sites 1 and 3 was conducted to: (1) develop an RI report based on evaluation of Round One and Round Two field investigation results; (2) assess the nature and extent of contamination at each site and/or to identify data gaps preventing an adequate understanding of site conditions; and (3) assess potential human health and ecological risks associated with any contamination at Sites 1 and 3. To address data gaps from the Round One investigation, a second round of field investigative activities was completed. These activities included installation of monitoring wells and collection of surface and subsurface soil, surface water, sediment, biota, and groundwater samples.

This section presents an itemized summary of the results of the Round Two RI for Sites 1 and 3. The summary is focused on the nature and extent of contamination at the sites in addition to the results of the baseline human health and ecological RAs. The significant findings of this investigation are presented in the following paragraphs. Following the summary are conclusions based on the results of the Round One and Round Two RIs.

8.1 Summary

Site 1 - Investigative Results

Surface Soil

Generally, low concentrations of SVOCs (mainly PAHs) were detected within surface soil samples. Low concentrations of the pesticide compounds dieldrin, 4,4-DDT, alpha-chlordane, and gamma-chlordane were detected at within one sample and low levels of aroclor-1260 was detected in one sample. Nitramine compounds were not detected in any surface soil samples. The contaminants detected in the surface soil may be attributed to past disposal practices but they have not impacted the surface water or sediment of Indian Field Creek.

Subsurface Soil

Subsurface soil samples collected at soil boring and test pit locations. No VOCs were detected in the subsurface soils. Low concentrations of SVOCs were detected at three locations within the western portion of the site. Six pesticide compounds were detected within one sample at relatively low concentrations. Similar compounds and concentrations were detected in the surficial soil sample collected at this location. In addition, one PCB compound was detected at low concentrations at the same location but at a greater depth (3- to 5-ft bgs). Nitramines were not detected in the subsurface soil samples. The subsurface soil at Site 1 has not been significantly impacted by past operations and there is no apparent source or discernable pattern of the contamination. The analytical results for subsurface soil indicates that it is not acting as a source for the groundwater degradation at the site.

Four test pits were excavated within the suspected landfill area. The test pits were excavated to depths of 4.5- to 8-feet bgs when the natural soil horizon was determined. The fill material consisted of sandy soil with a mixture of debris (concrete, scrap metal, styrofoam, wood, rail road ties, and tree limbs) In addition, a 6- to 8-inch layer of white lenses grinding dust was encountered at approximately 3-feet bgs within 1TP04. The results of test pitting determined that the landfill does not extend north of the road at this location.

Groundwater

The following subsections summarize the analytical results for the shallow and deep groundwater.

Shallow groundwater

VOCs, SVOCs, and nitramines were detected in six of the eleven shallow groundwater samples collected at Site 1. Three of the monitoring wells had concentrations of 1,2-dichloroethene and trichloroethene. The highest concentration of trichloroethene (190 µg/L) detected in 1GW20 exceeded the Federal maximum contaminant levels (MCLs) and the Virginia MCLs. Low concentrations of pentachlorophenol and nitrobenzene were detected in four of the samples collected. The VOC contamination is limited to the southwest portion of the site within the shallow (Columbia) aquifer .

Relatively low concentrations of total inorganics were detected in the shallow groundwater samples. Antimony, beryllium, mercury, nickel, silver, thallium and cyanide were not detected. Only cadmium (total and dissolved) exceeded the Federal MCLs at monitoring well 1GW12.

Deep groundwater

VOCs, and SVOCs were detected in three of the six deep groundwater samples. TCE was detected in three of the monitoring wells at a maximum concentration of 360 µg/L in 1GW12B. This concentration exceeded both the Federal MCLs and the Virginia MCLs. This well was located near an area where TCE was detected in the shallow groundwater (1GW20 at 190 µg/L). Low concentrations of SVOCs were detected in at three of the six deep monitoring wells. The VOC contamination is limited to the upper portion of the site within the deep (Cornwallis Cave/Yorktown-Eastover) aquifer .

Fifteen of 20 inorganics were detected at relatively low concentrations. Antimony, mercury, silver, thallium, and cyanide were not detected. Only chromium exceeded the Federal MCLs. Federal or state of Virginia groundwater criteria was not exceeded by of the dissolved inorganic sample concentrations.

Surface Water

No VOCs, SVOCs, or pesticides/PCBs were detected in the samples and inorganic concentrations were relatively low.

Sediment

VOCs, SVOCs, and pesticides/PCBs were not detected in any of the sediment samples and inorganic concentrations were relatively low.

Site 3 - Investigative Results

Surface Soil

Low concentrations of SVOCs, mainly PAHs were detected within one (3SB08A-00) of the sixteen surface soil samples collected at Site 3. A second sample 3SS10 had detections of similar PAHs but at elevated concentrations. The confirmation sample results at the 3SS10 location indicated that the elevated PAH concentrations are limited to the surficial soil within a small area. In addition, low concentrations of pesticides were detected in two samples. Sample 3SS11 had low concentrations (31 mg/Kg) of the PCB aroclor-1260. Nitramine compounds were not detected in any surface soil samples. The contaminants (SVOCs and PCBs) may be attributed to past operations but the pesticides are consistent with historical use of Station-wide spraying.

Confirmation soil sample results

On August 26, 1996, five confirmatory surface (0- to 6-inches) and one subsurface (18- to 24-inches) soil samples were collected around the 3SS10 sample location. The samples were analyzed for SVOC. Further inspection of the sample locations showed a "tar-like" substance within the surficial soil (0- to 6-inches). The analytical results showed similar PAH compounds but at greatly reduced concentrations except in Sample 3SS10C which had similar concentrations as 3SS10.

Subsurface Soil

Low to moderate levels of VOCs were detected at two locations 3SB15A (15- to 17-feet bgs) and 3TP02 (including the duplicate) from 8- to 9-feet bgs. VOCs were not detected in 3SB15A at the 23-to 25 foot interval. Relatively low concentrations of SVOCs were detected at 3SB15A at 23- to 25 feet bgs and at 3TP02 at 8- to 9-feet bgs. Low levels of pesticides were also detected at these same locations and depths. These contaminants may be the result of past disposal practices at the landfill.

Groundwater

Results of the Round Two RI were consistent with VOC contamination (chlorinated solvents) detected in the Round One RI. The highest concentrations of VOCs were detected at 3GW19 installed within the shallow portions of the Cornwallis Cave/Yorktown-Eastover aquifer with concentrations of vinyl chloride at 48 µg/L, 1,1-dichloroethene at 4 µg/L, 1,2-dichloroethene at 570 µg/L, and trichloroethene at 860 µg/L.

The groundwater samples collected at greater depths within this same aquifer showed a significant decrease of VOC concentrations. The highest levels were located at 3GW19A (adjacent to 3GW19) which had concentrations of 1,2-dichloroethene at 24 µg/L and trichloroethene at 24 µg/L.

Concentrations of total inorganics in groundwater were generally within the range of the station-wide levels except at 3GW19A where chromium exceeded the Federal and the state of Virginia MCLs at a concentration of 177 µg/L and lead exceeded the Federal MCL at a concentration of 22 µg/L.

Summary of Human Health and Ecological Risk Assessments for Sites 1 and 3

The total ICR values estimated for the current adult and adolescent on-Station trespassers exceeded the USEPA's target risk range of 1 x 10-06 to 1 x 10-04 at both Site 1 and Site 3. This is due to the potential exposure to the Site 3 SVOC AOC (mainly the PAH benzo(a)pyrene) in surface soil. However, a removal action is recommended for this "hot spot" area and it is unlikely that adverse affects would result from exposure to Site 3 surface soil.

The total ICR values estimated for future residential receptors exceeded the USEPA's target risk range of 1 x 10-06 to 1 x 10-04 at both Site 1 and Site 3. This is primarily due to the contaminants detected in groundwater. The individual ICRs for soil (surface and subsurface) and the shallow Columbia aquifer were within the target risk range. Primarily due to the presence of vinyl chloride in the Cornwallis Cave/Yorktown-Eastover aquifer the ICRs for adult and child receptors exceeded the acceptable target risk range.

The HI values for future resident adults and children were greater than 1.0, suggesting that noncarcinogenic adverse effects may occur subsequent to exposure. For the most part, elevated total HI values were due to contaminants (1,2-DCE and TCE) in the two aquifers.

Results of the ecological risk assessment at Sites 1 indicated a risk to the terrestrial environment from inorganics in surface soil. The main driver of risk at Site 1 is lead which was detected at only three locations at concentrations slightly above normal background 95% UCL (background UCL). Therefore, the concentrations of lead in surface soil at Site 1 pose no significant risk to the environment.

Risk to the terrestrial environment at Site 3 is demonstrated by exceedences of background UCL concentrations for antimony, chromium, lead, and vanadium. Detections of antimony in samples 3SS11 and the duplicate (3SS11D) varied significantly. Sample 3SS11 had a concentration of 4.8L mg/kg and the duplicate had a concentration of 16.8L mg/kg. Both sample concentrations were validated as biased low (L) although the duplicate sample concentrations are nearly four times greater the original sample. The results of the duplicate sample is suspect and the original sample slightly exceeds background UCL levels. The concentrations of chromium and vanadium are similar to background UCL concentrations. The concentrations of lead are similar to background UCL concentrations with the exception of two locations 3SB08A and 3SB15A which are sporadic occurrences. Therefore, these concentrations of inorganics do not pose a significant risk to the terrestrial environment.

The concentrations of PAHs at Site 3 (SVOC-AOC) in the surface soil did cause risk to the environment mainly driven by elevated concentrations of benzo (a) pyrene. In addition to the PAHs, concentrations of inorganics also caused risk.

Concentrations of iron and lead in sediment were the drivers of risk within the aquatic environment. The concentrations of iron were slightly above background UCLs and concentrations of lead also exceeded background UCLs but not significantly. In addition, lead was only detected at one location. Therefore, risk to the aquatic environment from inorganic concentrations in sediment is not significant.

8.2 Conclusions

The horizontal and vertical extent of groundwater VOC contamination within the shallow and deep aquifers at both sites has been defined.

The analytical data suggests that upgradient sources of the VOC contamination within the landfill at Site 1 does not exist and the presence of DNAPL was not observed within the subsurface soil obtained during monitoring well installation.

There were no human health or ecological risks associated with the surface or subsurface soils at Sites 1 or 3 with the exception of the SVOC AOC at Site 3.

The results of the ecological risk assessment indicate a minimal threat to the environment.

PAHs (mainly benzo(a)pyrene) are driving the human health risk for the current adult and adolescent on-Station trespassers resulting from exposure to the SVOC AOC at Site 3.

Results of the human health risk assessment indicate noncarcinogenic and carcinogenic risks for the future residential scenario as a result of exposure to the shallow (Columbia) aquifer and the deeper (Cornwallis Cave/Yorktown-Eastover) aquifer.

The groundwater (shallow and deep) at WPNSTA Yorktown is not currently being used and will not be used in the future as a potable source given the mission of the station. The poor water quality is a result of hardness, high pH, and low yield that reflects the characteristics of a Class III aquifer which do not adhere to the water quality criteria of a drinking water aquifer. In addition, Sites 1 and 3 are within the WPNSTA Yorktown safety quantity distance (ESQD) arc (areas restricted to ordnance-related facilities) and as such, residential usage of the sites is prohibited.

Results of the RI and Baseline Risk Assessment dictate the following:

- No further action is required at Sites 1 and 3 with respect to groundwater (restrictions on the use of groundwater as a potable source will be applied.

- No further action is required at Sites 1 and 3 with respect to soil after a limited removal of surface soil at the SVOC "hot spot" at Site 3. The limits of the removal action will be determined by confirming the absence of PAHs through field test kit analysis and the collection of confirmatory soil samples (surface and shallow subsurface;< 3-ft bgs) sent to a laboratory for SVOC analysis.